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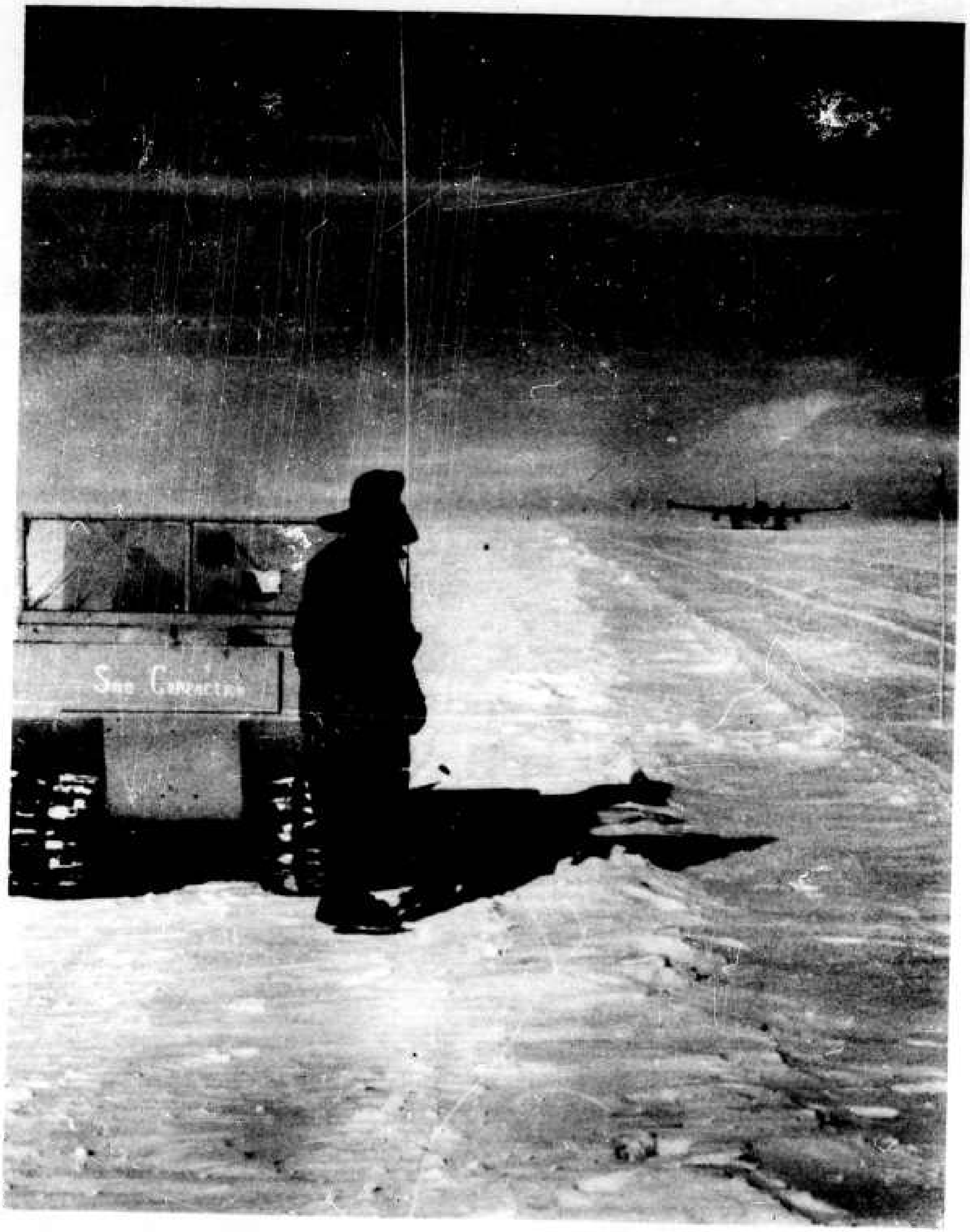
Technical Report 155

TECHNICAL DATA FROM DEEP FREEZE I, II, AND III REPORTS (1955 to 1958)

24 April 1961

U. S. NAVAL CIVIL ENGINEERING LABORATORY

Port Hueneme, California



TECHNICAL DATA FROM DEEP FREEZE I, II, and III REPORTS (1955 to 1958)

Y-F015-11-002

Type B   Final Report

Compiled by

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OBJECT OF TASK

To compile and analyze by technical subject matter the information contained in the reports issued on the 1955-57 Construction Battalion operations in the antarctic, and to present the technical data in a form that can be used as a ready reference.

FOREWORD

This report is a compilation of technical data obtained principally from the fourteen volumes of reports prepared by Mobile Construction Battalion (Special) for Operations Deep Freeze I, II, and III. Supplemental information was obtained from correspondence and situation reports originated by Deep Freeze forces, and reports of military and professional civilian observers, which are listed in the References and Bibliography.

The information is grouped into fifteen general technical subject areas, which are subdivided into specific problem areas. Within the problem areas the data are presented by individual U. S. antarctic stations whenever different environmental, topographical, or operational conditions contributed diverse solutions for the same or similar problems.

The object of the compilation is to provide a ready reference for persons concerned with the design, construction, maintenance, and operation of equipment and facilities in the antarctic. It is recognized that the information is historical and pertains to specific or limited sections of the South Polar area. However, the sources utilized in compiling this report are the only documentations of large-scale construction and continuing naval shore-based operations in Antarctica.

This record is a compendium of other people's work; the statements, conclusions, and recommendations are those of the original authors. Every effort has been made to faithfully reproduce the original text and to avoid distortion resulting from removing statements from their context. Although considerable irrelevant detail has been omitted, sufficient background information is retained to orient the reader and engender a better understanding of the circumstances attendant to problems unique to the antarctic. It is not intended that this report be narrative in format nor contain a chronology of Deep Freeze operations.

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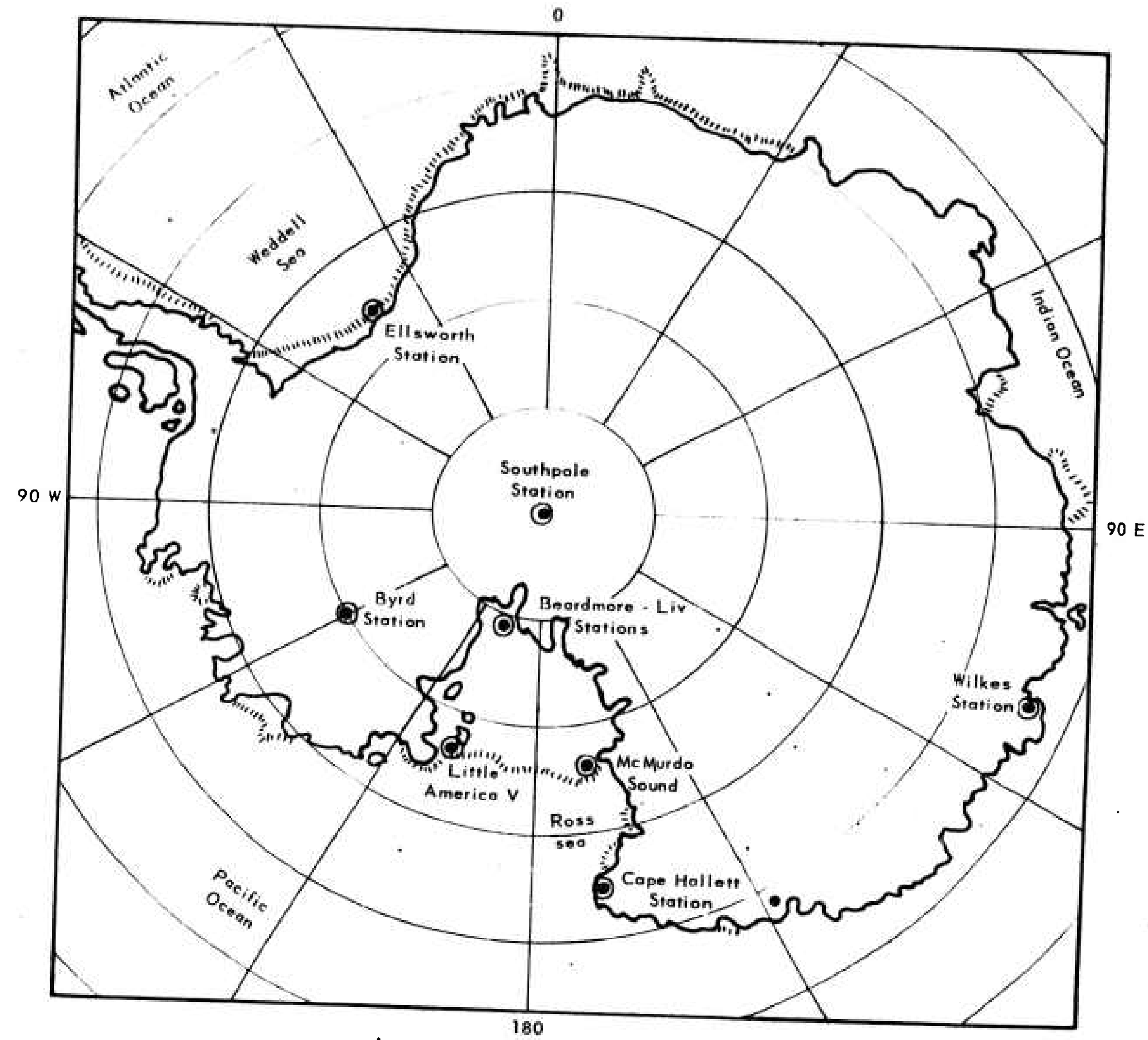

Figure 1. Antarctica.

Section I

GENERAL COMMENTS

INTRODUCTION AND BACKGROUND

In support of the antarctic scientific program for the International Geophysical Year (1957-58), MCB (Special) and MCB-ONE constructed seven bases and one pioneer support camp (Figure I). The main bases at McMurdo Sound and Little America were begun during the antarctic summer of 1955-56, and were occupied during the winter of 1956 by 166 men. The remaining stations were established during the second summer (1956-57).

McMURDO BASE, on Ross Island, was built on a foundation of volcanic material where permafrost was a consideration. However, operations were conducted primarily over perennial bay ice and deep snow on the Ross Ice Shelf.

LITTLE AMERICA was located on the deep snow of the Ross Ice Shelf adjacent to Kainan Bay.

BYRD STATION was constructed on the deep snow of the Rockefeller Plateau in Marie Byrd Land.

The SOUTH POLE STATION was located on the deep snow of the 9200-foot-high Polar Plateau.

HALLETT STATION, on Moubray Bay, was constructed over the heavily penguin guano-covered rocky coast of Victoria Land.

WILKES STATION was erected on the gravel-covered rock of Clark Peninsula in the Windmill Islands on the Budd Coast.

ELLSWORTH STATION, on the Weddell Sea, was situated on the deep snow cover of the Filchner Ice Shelf.

BEARDMORE, an auxiliary air facility, was established on the deep snow of the Ross Ice Shelf near the foot of Liv Glacier.

United States Naval Mobile Construction Battalion (Special) was formed in February 1955 as part of the Construction Battalions, U. S. Atlantic Fleet. The battalion was commissioned at the Construction Battalion Center, Davisville, R.I., on 23 July 1955, and became a task group under the overall command of Commander Task Force Forty-Three, which had the mission of providing logistic support for the United States participation in the antarctic phase of the International Geophysical Year (1957-58). Other task groups of the task force included Experimental Development Squadron SIX (VX-6), ships of the fleet, and various echelons of the staff of Task Force Forty-Three.

During the summer and early fall of 1955, prior to departure, the battalion performed many tasks; training of personnel and procurement of material and equipment were perhaps the greatest tasks accomplished. Six or seven months was a very short time to weld a group of men into a working organization for the mission assigned. The fact that the cargo had to be split up in order to be shipped to each area was a job of great magnitude itself. Every box of nails, every load of fuel and every container of spare parts, had to be divided for shipment. One of the primary reasons the job was so difficult in the formative stage was that construction would be spread out over a great area. Because of the difference in nature of the areas in which the stations were to be constructed, each had to be treated separately from an engineering standpoint.

During Operation Deep Freeze I, a detachment of MCB (Special) was deployed to Kainan Bay, which was to be the site of the main scientific base known as Little America V (hereinafter referred to as Little America); and another detachment was deployed to McMurdo Sound, which was to be the site of the main logistics base known as Williams Air Operating Facility (hereinafter referred to as McMurdo). The distance between the bases was 393 miles.

The task force departed the continental United States between late October and mid-November, 1955. An advanced party reached the ice at McMurdo Sound on 18 December, and VX-6 aircraft arrived from New Zealand on 20 December. Within a week a pioneer camp was established at Hut Point, 45 miles from the ships. Advanced equipment and materials were off-loaded from the icebreakers, and the cargo ships were tied up to the ice edge. Plagued by bad weather, deteriorating ice pack, erratic ship-to-shore communications, and a series of mishaps, construction personnel were delayed in starting the permanent camp at McMurdo until 12 January 1956.

Aircraft support, ice-pack conditions, and operational requirements at McMurdo delayed arrival of the Little America forces until the end of December. Also plagued with precarious ice conditions, this group quickly off-loaded advanced equipment and materials, and began construction of the permanent camp. The Little America base was commissioned on 4 January 1956.

Accelerated ice deterioration necessitated a fly-out of VX-6 aircraft from McMurdo on 18 January and a stepping-up of ship unloading operations at both stations. Simultaneously, camp construction, including POL storage facilities, was accelerated. Cargo ships departed by mid-February, and the last of the task force ships by early March. From then until late October 1956 there was no logistic support and no means of evacuation from either base. The only means of communication with the outside world, and, for that matter, between the antarctic bases, was by radio.

Construction of the main bases continued at a rapid pace, and by mid-April the first season's construction was essentially completed. At Little America this included a 6000-foot ski runway, and support facilities at Kiel Field.

The wintering-over party consisted of 93 men at McMurdo and 73 men at Little America. During the long winter night and early spring (April to November 1956), the men devoted their many hours of isolated existence to accomplishing a variety of important tasks. The interiors of the many camp buildings were completed. Supplies, construction materials, and equipment were dug out of cache, sorted, and repacked in preparation for the construction of the advanced camps at the South Pole, in Byrd Land, and near Beardmore Glacier during the second summer. Construction parties were designated and plans finalized. At McMurdo, MCB (Special) personnel struggled with the elements and equipment failures in an endeavor to construct a permanent airstrip on the Ross Ice Shelf.

Even as early as the beginning of the antarctic winter (April 1956), preparations for Deep Freeze II were implemented. While Detachment ONE personnel were completing the construction of the main antarctic bases, MCB (Special) Detachment BRAVO was being formed at CBC, Davisville, R.I. This detachment, which was commissioned on 24 August 1956, was to relieve Detachment ONE during the summer of 1956-57 and winter over during Operation Deep Freeze II. Prior to deployment, Detachment BRAVO personnel were subjected to an intensive indoctrination and training program.

Beginning in September, and extending into December 1956, Detachment BRAVO and MCB-ONE personnel were deployed by ship and plane to their various assignments in the antarctic. Detachment ONE wintering-over groups departed from the main bases to build three stations further inland. Personnel from Little America built a station in Marie Byrd Land. McMurdo personnel built the Beardmore Auxiliary Air Base (later called Liv Glacier Station) and the station at the geographical South Pole.

Assisted by MCB (Special) Detachment BRAVO, MCB-ONE established three additional stations in the vicinities of Cape Adare, the Knox Coast, and Cape Adams on the Weddell Sea. MCB-ONE personnel also supplemented MCB (Special) forces at McMurdo and Little America during the summer period. After relieving Detachment ONE, Detachment BRAVO completed construction of the Byrd and South Pole Stations and new facilities at Little America and McMurdo.

About mid-October 1956, the VX-6 aircraft returned to McMurdo, ending the long period of isolation and signaling the start of the new construction season. Within a week the first Air Force C-124 landed on the ice runway, and by the end of the month the first task force resupply ship reached McMurdo. Aerial reconnaissance of the proposed stations in Byrd Land and at the geographical South Pole, and of the auxiliary air base near Beardmore Glacier, quickly followed the return of the support units. A surface reconnaissance team departed Little America to establish a trail to the Byrd Station. On 31 October, Admiral Dufek and party made the first landing at the South Pole.

Despite adverse weather and a deteriorating ice runway at McMurdo, construction was started at the Pole on 20 November. The Beardmore base had been established near the end of October. The trail party from Little America progressed rapidly to the edge of the extensive crevasse area abutting the Rockefeller Plateau. Crossing this 7.5 miles required two weeks of aerial and ground search, blasting and dozing, and occasional backtracking for fresh starts. On 23 December the first tractor-train reached the Byrd Station site, and construction started.

Construction of the Hallett Station near Cape Adare was delayed first by the heavy Ross Sea ice pack and secondly by the diversion of the task group to assist in unloading at McMurdo. By 29 December 1956 the task group had returned to its original mission and an aerial reconnaissance party selected a base site on a low-lying spit off Cape Hallett. Again construction was delayed, first by the necessity to relocate a large Adelie penguin rookery and secondly by several days of storm-force winds. Following the storm, all cargo was unloaded via amphibious craft and construction was begun. On 10 January the task group was again diverted to McMurdo to assist in unloading operations, leaving the wintering-over party and 32 officers and men of MCB-ONE to complete the Hallett Station.

With unloading operations nearly completed, the Knox Coast (Wilkes Station) task group was released and it proceeded to the locale at Vincennes Bay. On 31 January 1957 an underwater demolition team blasted a landing ramp in the ice pack and construction materials streamed ashore. Within fifteen days the construction forces had completed the entire camp.

From the beginning the establishment of the Ellsworth Station was beset by delay. After more than one month of continuous battling with the most formidable of ice conditions, a camp site was selected east of Gould Bay. Construction finally began on 28 January 1957. The imminent danger of the ice shelf calving under repeated heavy weights impeded cargo unloading. Nevertheless, by working around the clock, unloading was completed in twelve days. Construction was 90 percent complete and the base self-sufficient on 11 February, when deteriorating weather conditions dictated withdrawal of the task group ships.

The Beardmore and South Pole Stations were totally supported by airlift; Byrd Station was supported by a combination of airlift and tractor-train operations. Beginning in late December 1956, the MCB (Special) Detachment ONE personnel at the inland bases were gradually replaced by Detachment BRAVO personnel and evacuated to the main bases. By 30 January 1957 all Deep Freeze I MCB (Special) personnel were aboard ship for return to the United States. Enroute north, the MCB-ONE construction party was evacuated from Cape Hallett.

Most of the task force ships departed the antarctic between 10 and 25 February 1957. One icebreaker returned about mid-March to deliver mail and late cargo to the three bases on the Ross Sea. Wintering-over parties continued to improve the base facilities, and during the long winter night assisted in the scientific programs assigned to the various stations. At Little America, the geomagnetic buildings were moved out of a ferrous-metal contaminated area. On 28 April McMurdo suffered a severe setback when the garage was totally consumed by fire. Lost were a D8 tractor, all special shop tools, practically all hand tools, and parts catalogs and maintenance manuals.

Wintering-over at the seven stations were 324 military personnel and civilian scientists, with the largest groups at Little America and McMurdo. With the return of twilight, and later, daylight, the stations directed a major effort toward the coming summer operations. A skiway and a new ice runway were prepared at McMurdo. On 3 September 1957, two R4D aircraft flew from Little America to McMurdo, and by the end of the month had assisted in re-establishing the auxiliary air base near Liv Glacier. Summer operations began on 1 October when three VX-6 aircraft arrived from New Zealand. Three days later the first C-124 landed. The first airdrop of the Deep Freeze III season was accomplished on 17 October at the Pole Station. Soon after the middle of November, Detachment BRAVO personnel began the exodus, and Deep Freeze III personnel took over.

SELECTION AND TRAINING OF PERSONNEL

Selection of Personnel

All of the men assigned to MCB (Special) Detachment One were volunteers, obtained from the fleet through an ALNAV and subsequent screening. There were small men, large men, extroverts, introverts, adventurous men, studious men, family men, and single men. Motivations varied widely from individual to individual. Some wanted to save money; others wanted the experience itself; still others were seeking adventure. Most were career naval personnel with very tangible reasons in most instances for this choice of duty. Many thought that the antarctic duty would help their naval careers. Others who were due for sea duty felt that it didn't make too much difference where they "put in time - it all counts on twenty."

To the individual himself, the type and degree of motivation are most important indices of how he will fare during the winter of isolation. The individual who goes to the antarctic in order to get something out of it (scientific data, photographs, cold-weather experience) will probably be a happier and more contented individual who has far greater immunity to the unpleasantness of isolation than does the man who drifts into the job.

To the group, the individual's motivation is important only in that it is an index to the quantity and quality of the work he produces while on the ice. If a man can give a specific reason for wanting to go to the antarctic, and follow it up with an outline of his proposed program, he will be apt to produce better results than the man who just follows the crowd and can give no account of his plans prior to departure.

To the selection group who must choose men for polar duty, however, motivation per se must be de-emphasized as a screening factor. To understand why motivation is less important in polar duty than in other duties, one must be fully aware of the unique differences in isolated duty. It must be made clear that in the small station, where men live together for ten or eleven months without outside contact, teamwork is vital. The overall success or failure of the group is more dependent on teamwork than on the individuals themselves. The men must work together, and hence the fundamental quality, the least common denominator, of all men must be the spirit of cooperation. A man can be "highly" motivated and "well" motivated, and yet still have a personality which is uncongenial and uncooperative.

The selection of individuals must also be the selection of a compatible group. Any men who do not appear to fit in should be eliminated from any small base, as one misfit can become a source of definite trouble for all later on.

All members of Deep Freeze I were observed during the 2-1/2-month construction period in the antarctic from December 1955 to March 1956. Those who appeared unsuitable for wintering over were returned to the United States. Moreover, at the time of departure of the ships, personnel who had changed their minds about wintering over were given the opportunity to withdraw. Hence, the wintering party was a highly selected group. Many judgments made at home about the suitability of personnel for wintering over were not confirmed in actual experience during the summer operations. Some who were expected to perform very well became depressed or dissatisfied, and others about whom there had been some doubt showed unexpectedly high morale and good performance. There is no doubt that the high caliber of the final wintering party was increased by the opportunity for final selection after observation in the antarctic. The wintering-over personnel selected proved to be a very stable group. In testimony to this is the fact that there were no disciplinary actions necessary.

Among those who had initially volunteered to winter over and later requested to be returned to the United States, the chief factor in the change of mind appeared to be disillusionment about living and working conditions.

Civilian technicians have a definite place in the construction of certain specialized structures, as was the case concerning the fuel tanks built in 1956 and 1957 at McMurdo. No difficulties are experienced as long as the civilians who are at the working level remain at the working level, and civilians in a supervisory status work through the various officers assigned to a project. Policy and plans determined by civilians should be administered through the military leaders.

Recommended Selection Procedures. Standard Navy procedure should be used in peace-time operations just as they would be in time of war. The value of the use of volunteers is extremely questionable. The only particular in which antarctic duty imposes special hardship is in the impossibility of evacuation of personnel during the winter night. Otherwise, there are many other duty stations with comparable psychological and physical difficulties.

Care should be taken in selecting personnel for the period of isolation to avoid, as far as possible, choosing men who might need evacuation before relief arrives. Any personnel with a past history of any limiting physical factor which could reoccur should be eliminated. Physical standards cannot be too high.

Visual restrictions need not be severe for duty in the antarctic. However, it should be recognized that in very cold outdoor work, the individual requiring visual correction may be unable to wear his glasses because of the fogging which results from his breath within a matter of a few minutes. It might be recommended, therefore, that any key individuals be fitted with contact lenses if corrections are necessary. It appears that the routine antifog compounds for eyeglasses are ineffectual.

Another condition which deserves mention is that of hernia. Any suggestion of hernia should be disqualifying, since the conditions predispose to acute herniation with all the possible serious complications which might be most difficult to manage at an isolated station in the antarctic.

Emotional stability is of importance. While not necessarily a function of age, problems of this nature during Deep Freeze I were most prevalent among the younger men. In general, the performance and stability of the men under twenty-five was below that of the older men. However, there were exceptions on both sides of this age line, and emotional stability should be considered apart from calendar age.

Younger men, however, have the added disadvantage of more limited experience. Candidates should be evaluated psychiatrically to weed out obvious personality traits which would be undesirable in the circumstances of close living inherent in antarctic operations. In general, the most valuable men both from the standpoint of job accomplishment and that of getting along well with the groups were those with rural or small-town backgrounds.

No promises of ensuing privileges should be made. The officers and men should be processed through the selection procedure on the basis of qualifications desired. It is important to the successful adjustment to the wintering-over situation that all participants have an accurate concept of the nature of their assignment before selections are made final. Personnel selected should be made aware of the fact that they will be called upon, as needed, to perform work outside of their specialty. Only if individuals perform jobs according to immediate requirements rather than within their rate can the limited manpower available be effectively utilized. It is imperative that the individual selected for this duty be looking forward to the problems and difficulties of the operation - and to its reward as well - with maturity and realism. In some instances, unintentional misrepresentation and vague concepts of the forthcoming assignment impair the ability to adjust to the actual situation.

Personnel must be capable technically, flexible in their thinking, compatible, and in good physical condition. A technically incapable man quickly becomes frustrated under pressure. An inflexible man will not be able to compromise, as is so often necessary. Living in close association with others, he will be subjected to intense physical and mental strain. If he is basically interested in the work without illusions of grandeur, he will not become morose when he finds out that the antarctic means a great deal of work and little glory.

The desirability of any candidate can be judged only in the light of his actual performance within the group and at his job during the period prior to deployment. The group should be formed early at Davisville and trained together.

If a member of the military service is competent in his rate or rank, has drive and determination, takes pride in the performance of his duties, and has an adequate share of "intestinal fortitude," he need not be any special superman. Previous cold-weather experience and/or experience in constructing and operating snow and ice runways is highly desirable, although not a necessity.

Training of Personnel -

Prior to deployment, the training of personnel was a prime consideration. Men were sent throughout the nation to obtain necessary information in connection with the job to be performed in the antarctic. Some were briefly deployed to Greenland to observe techniques of construction devised in the north, living on the icecap, building snow runways, survival, and tractor-train operations. Others were sent to commercial training schools on the equipment being furnished the battalion. Men were sent to military schools at Camp LeJeune, to learn about fuel-handling systems, and at Fort Belvoir, to learn special demolition techniques for use on ice, snow, and permafrost. Personnel were sent to Detroit to erect a test building under simulated antarctic conditions, to Los Angeles to learn about the radar equipment to be installed, and to Port Hueneme, California, to observe the fabrication of special wanigans and snow-compaction equipment developed by NCEL. Fire fighting, radio suppression, and washing-machine repair schools were also attended by certain ratings.

Recommended Training. All personnel should receive training in the operation and maintenance of any and all equipment in their line with which they are not already familiar. For duty at a small base, all men should know how to operate and service the mechanized equipment to be assigned that base, as its operation very often falls upon men other than drivers or mechanics. Radio and electronics personnel should be acquainted beforehand with any nonstandard equipment, especially commercial gear. Electronics technicians should also be able to copy and send CW traffic if the need should arise.

Basic cold-weather survival indoctrination should be given to all personnel prior to their arrival in the antarctic, particularly concerning the clothing that they will have. Though most of the necessary survival training can be given at the individual bases, basic familiarity with equipment and procedures should be attained in advance. The training should be fairly comprehensive in the case of men who are likely to be involved in overland travel. Men who are to be in a crevassed area should also be trained in crevasse rescue and ice mountaineering. Survival training should include such subjects as manhauling sleds, erection of trail tents, preparation of rations and water, operation of stoves, care of clothes on the trail, proper dress for trail work, care and use of sleeping bags, operation of portable radio equipment, general trail routines, antarctic geography, first aid, and survival techniques.

SURVIVAL PLANNING AND RESCUE OPERATIONS

Concepts of Survival

Basically, a survival technique was desired that would allow personnel, isolated anywhere on the antarctic continent, be it a result of plane wreck or of intentional design, to have survival gear available to survive for a period of 45 days under minimum efforts and to effect heavy construction efforts for a period of 15 days without any support. Although each aircraft would have basic survival gear aboard, it was highly desirable for an operation to plan further than basic survival. The gear which would allow the accomplishment of the basic technique might have to be carried by the personnel.

At Byrd, the establishment of an emergency cache was undertaken as soon as urgent construction work was completed. The cache contained provisions, medical supplies, clothing and survival equipment. Clothing and medical supplies were placed in large metal boxes and stowed in Sno-Cats which were parked several hundred yards from the buildings. Later, food and survival gear was selected and placed on board another Sno-Cat. With the preparation of the Sno-Cats for the IGY traverse in the spring, the cache material was off-loaded onto a 1-ton sled, which was hauled to another area away from the camp and marked by flags.

The Pole Station, located over 350 miles from the nearest support activity, is another example of a remote and isolated base where survival is paramount. If a plane flying to the Pole were forced down enroute, or if personnel were landed at the Pole and subsequent support flights were delayed, each man was to have sufficient equipment to be self-sufficient without stripping a plane of its survival gear.

In case of an aircraft crash, aircraft wreckage can be erected as a shelter in which to administer first aid to the wounded and make them comfortable. If the extra clothing and sleeping bags placed aboard the aircraft are not ruined, they can certainly be utilized, but sufficient blankets should be flown to the site aboard the first rescue aircraft. The quickest and most reliable method of searching for and rescuing lost personnel is by helicopter, or ski-equipped aircraft. The first aircraft should carry a Jamesway hut with stove and oil, in addition to a doctor, corpsman, and medical supplies. Evacuation of patients should be effected on each return flight until all are returned and the camp is disassembled.

One other basic requirement desired was a certain degree of mobility. Each group would have a limited manhauling capacity to move to accessible terrain or, with frequent air support, to move longer distances to safety in the event an aircraft could not land to effect a rescue. In the case of the Pole construction, the party was divided into teams of four men each.

The team was equipped and trained to act as a unit in case of emergency. Four men made an ideal unit, as four men and the gear required to accomplish the basic survival aims amounted to less than 2000 pounds; a good load for an R4D aircraft. It also provided a good margin of safety in case one man was incapacitated. Manhauling, however, is far from an ideal solution to polar travel. The teams were indoctrinated not to move from the site of a crash unless absolutely necessary. A team could survive more than twice as long sitting still than it could moving on the trail. This was particularly true at the high altitides of the Polar Plateau and in the deep, soft snow found there.

Antarctic food sources are almost nil, but penguins, seals, and fish may be available along the seacoast. People have sustained themselves on penguin meat, and the blubber can be used as a source of fuel. These birds can be caught by virtually any method, and usually are easy to catch but are difficult to hold. Care must be used in handling the bird alive since its beak can cause severe injury to eyes or other portions of the body, and the flippers of a full-grown emperor penguin can strike with enough force to break an arm.

A seal may be caught by hitting it in the head with an instrument such as an ax or club, or by slitting the animal's throat with a hunting knife. Seal steaks are probably best taken from around the neck area and are not too untasty, although they are reported to have a slightly tangy flavor. Seal liver is a real delicacy. Other edible antarctic life would be various forms of marine life; however, difficulty in obtaining such items makes this almost impractical unless fishing gear is available.

Water can obviously be made by melting snow. Soft snow may be eaten but should be eaten cautiously to avoid blistering of the oral area.

Manhauling capabilities are extremely limited in the rarified air and soft snow encountered at the Pole. On the Plateau, each mode of transport - manhaul, dogs, weasel - has a different economical speed of advance. Manhauling might be expected to progress at a maximum of 10 miles per day, or about one mile per hour, and result in exhausted personnel. A dog team, however, can travel about twice this rate of speed, or 20 miles per day. It can carry a heavy load (each dog will pull about twice its own weight) without serious fatigue on the part of the men participating. A weasel, reduced in power because of altitude, can travel between 3 and 6 miles per hour, in proportion to its load and the surface characteristics. Forty miles per day might be average, with no hardship on the men. If air support is available, and if terrain is relatively crevasse-free, weasels are highly desirable. If working in extremely isolated areas with reduced support facilities, or if working in highly crevassed areas, a dog team is desirable. Manhauling should be used only as a last resort.

The trail rations should be packed in large tin cans. Few men will eat a full ration unless they have exercised vigorously throughout the day, as in manhauling. With a minimum of energy expenditure, a man can survive on 400 calories per day for approximately 10 days, 1000 calories per day for approximately 20 days, and 2000 calories per day indefinitely.

Rescue Preparations

In the antarctic, subfreezing temperatures are often associated with blizzards and whiteouts. Consequently, if accidents occur, it is imperative that rescue operations commence immediately. A well-trained and specialized rescue squad must be maintained in order to facilitate and expedite rescue operations.

Though the search and rescue responsibility lay with AirDevRon Six, a search and rescue jump team composed of MCB (Special) Detachment One personnel was trained at Lakehurst in 1955, and the members wintered at McMurdo. The team consisted of three naval aviators, two qualified parachute jumpers, a medical officer, and two mechanics. Under the supervision of the senior member, this team maintained a high state of readiness for both aerial and surface SAR operations. Rescue facilities, as far as construction forces were concerned, included air facilities (a helicopter, Otter, and R4D) and surface rescue facilities (weasels, dog teams, outboard motorboat, etc.).

During the wintering period all rescue equipment was checked and, in view of the actual trail conditions that were found, numerous on-the-spot changes to the contents of the survival kits were made.

The greatest deficiency in planning and procurement lay in the field of survival gear for passengers aboard aircraft. Some planes carried absolutely no polar survival equipment for any passengers. As the number of personnel on a flight was often as many as 50, the McMurdo survival gear was frequently used. Most of the equipment given to passengers departing Antarctica for New Zealand was never returned. Recommendations were made that McMurdo be assigned the responsibility for the procurement, issuance, and custody of all such passenger kits.

The primary concern of all personnel leaving camp was: falling into crevasses or tide cracks, being caught in a blizzard away from camp, or being caught on an ice floe that had broken off from the edge of the sea ice. These hazards are dangerous usually only if one is alone, without survival equipment, or away from camp unknown to those in camp. A rigid check-out system was set up to preclude this happening, and persons were urged to travel away from camp in groups of two or more. Men traveling the trail in tractors were required to take minimum food and sleeping bags as the circumstances warrented. If men sit still when caught, and if if they have ample food and sleeping bags, there is little chance for harm to befall them. A helicopter was usually available, as well as outboard motor and boats, to handle those caught on a floe.

If one should become lost in a storm he should immediately seek shelter if any is available and remain in such shelter until the storm subsides. If shelter is not available, he should sit down in a hunched position and place his head between his knees, with his back to the wind. Frequent movement of fingers and toes will aid circulation and help prevent frostbite. Of prime importance is that one should never wander aimlessly about as one's sense of direction becomes grossly confused.

The basic rules of survival are:

1. Keep a cool and clear head.

2. Attempt first aid, as necessary.

3. Do not leave the area of a downed aircraft.

4. Establish as comfortable a shelter as possible.

5. Make the best use possible of all clothing.

6. Utilize what food rations are available and, if the rare chance occurs where animal subsistence is possible, utilize such food and fuel as necessary.

7. Have signals ready for search aircraft.

8. Keep as dry as possible.

SUPPLY AND LOGISTICS

General Comments

The eight months prior to the departure of MCB (Special) for Antarctica were quite hectic supply-wise, especially since funds for the procurement of operating supplies were not available until after 1 July 1955. This resulted in the great bulk of MCB (Special) supplies arriving between the middle of September and the middle of October, instead of a more desirable steady flow of material. Much of the material had to be repacked, broken down by bases, and all had to be color-coded for the ultimate destination. In addition, all material had to be categorized for ultimate use and priority had to be assigned in accordance with the CTF-43 Operation Plan. Procurement regulations prohibited the purchase of proprietary or brandname products unless certain conditions were met, while in many cases a particular brand would have characteristics more suitable for use in the antarctic. Although all desired materials of this type were eventually procured, the justifications required were tedious and time-consuming.

All funds were allocated to MCB (Special) by BuDocks through ComCBlant. The supply officer of MCB (Special) did all the ordering of operating supplies and performed allotment accounting. Logistic support and the determination thereof for the bases was the responsibility of the Commander Task Force 43 and other stateside commands, bureaus and activities. Responsibility for support was generally delegated to commands having technical responsibility for the particular materials concerned. For example, the Navy Ships Store Office and the Provision Supply Office (now the Navy Subsistence Office) ordered ship's-store stock and food, respectively. Prior to actual ordering, both offices submitted lists of items to MCB (Special) for perusal and an opportunity to request additions and make recommendations.

Equipment preparation required a great deal of time in Davisville. All of the tractors and vehicles were procured on short notice and from all parts of the country. When they arrived in Davisville, most were directly off the production line. Every piece had to be thoroughly "broken in" before it could be loaded for shipment to the antarctic. It was absolutely essential that everything be in working order before the departure of the battalion for Antarctica. Even so, some items such as generators arrived at Davisville too late to be thoroughly tested before departure.

Material lists for Deep Freeze I were computed for each area. Because of the unknown factors involved, liberal contingencies were allowed and the number of items desired made the lists voluminous.

Most supplies and materials arrived barely in time to meet the ship sailings. Consequently, loading could not be accomplished in a fashion to produce the most efficient off-loading schedules upon arrival in the antarctic. For example, when the first ship arrived at Davisville, Rhode Island, for loading, there was less than 30 percent of the cargo on hand. Some of the cargo that arrived late had to be transshipped to Norfolk to catch late departing ships.

The reordering system used during Deep Freeze II was not satisfactory. A simplified, prearranged reordering system would be invaluable. "By November 1959 the reordering was almost all cut over to EAM procedure, including requirements. This is fully expected to provide the improvements desired."[12]

The base itself can best determine what items are needed first and requests for these items should be honored. The need for procurement and delivery of items in accordance with the requests of those who are actually at the bases, and who need and will use the material, cannot be too greatly stressed. "Support at the operating level was tremendous, and the main cause of annoyance was the nonreceipt of materials ordered from CONUS by Deep Freeze I wintering parties."[11]

Supply Organization

McMurdo

Upon the arrival of the majority of Deep Freeze II wintering-over personnel, the ships were all off-loaded except for drummed fuel. Most of the cargo was "dumped," not "stacked," in the various caches by category and base. This occurred as the result of an all-out effort to get the ships unloaded, but it unbalanced the manpower and equipment available for transferring, stacking, and recording the cargo in the various category stockpiles.

Because of the pressure of priority work, such as air operations, equipment repair, and construction, a sizable crew could not be allocated to straighten and inventory the stockpiles. Such work had to be done by the shops and departments concerned. This resulted in a rummaging operation for new spares and equipment.

The drummed POL was neatly stacked at the base of the hill along the Winter Quarters Bay side of Hut Point. Winter snows drifted in the area, and considerable difficulty was experienced in digging out this material in August when POL had to be moved to the runway supply area.

Little America

The Supply Department at Little America consisted of one Supply Officer and one Storekeeper First Class. The supply office was located in the building at Little America designated for IGY Weather Central. This building was evacuated the first week in January 1957. MCB-ONE personnel constructed three Jamesway huts (16 by 24), which were attached together by vestibules and connected to the main tunnel. These huts were heated by a Preway heater. The first Jamesway was designated and compartmented as the supply office and barber shop; the second Jamesway as the ship's store salesroom, and the third as a ready-issue storeroom for the ship's store.

Between 27 December 1956 and 2 January 1957, a site was located and laid out for use as a temporary supply depot at Little America. The site was located on the high part of the Ross Sea ice barrier about one mile from the edge of Kainan Bay and 2-1/2 miles from the main base. Two depots were laid out, one on each side of the main road leading between the off-loading area at Kainan Bay and Little America. One depot was for Byrd Station cargo and the other for Little America cargo. Fifty-foot roadways were laid out, between double (15-foot) rows of cargo space. Each row of cargo was marked by a letter flag indicating the category of cargo to be temporarily stored in the row. Ditches 7 feet wide, 200 feet long, and 15 feet deep were bulldozed out in the areas. These were used temporarily for frozen food storage. As frozen foods were placed in

the trenches, 6 to 8 feet of snow was shoveled or bulldozed over the provisions to lessen chances of defrosting. None defrosted.

The supply depot at Little America was manned 24 hours a day in two 12-hour shifts. Supply depot equipment consisted of three caterpillar D4 tractors with low-ground-pressure tracks. Two of these were fitted with fork lifts, and one with a boom. When required, a D8 tractor was made available to bulldoze the roadways in the supply dump. Two weasels with radios were assigned. One was used bv the field master to go between supply depot areas and the ship off-loading site to coordinate the off-loading. The other was used by the work crew to haul personnel and redistribute small items of cargo in the depots.

Cargo was hauled on 20-ton sleds to the storage sites as it was off-loaded from the ships. As many as four or five cargo trains, each consisting of a D8 tractor and two 20-ton sleds, might be unloaded at the same time. Since the number of cargo trains arriving for off-loading often exceeded the D4 tractor availability, it became necessary at times to push materials off sleds manually in order to maintain the proper turn-around time of trains.

On occasion cargo being off-loaded was switched from general cargo to POL drums for short periods to re-establish a balance between the turn-around rates at the ship and at the supply depot. This was possible because drums load slowly at ship-side, but can be rapidly off-loaded by pushing them off in rows from a moving sled. The distance of haul to the supply areas and the procedure of moving the entire tractor train about the supply depot while being off-loaded were the primary causes of occasonal lags in maintaining a steady rate of ship off-loading.

After the second Byrd tractor train departed on 28 January 1957 only two D8 tractors and six 20-ton sleds were available. One of the D8 tractors was required to act as the beach-side end of a house-fall rig, utilizing its A-frame and 38-ton weight to advantage. With only one D-8 available to haul 20-ton sleds, every other other available piece of equipment had to be fully utilized. A D2 tractor was used in emergencies to pull a reserve sled, and on occasion two sleds, under the boom of the ship. At times this relatively tiny machine was up to its hood in the soft snow and barely visible in front of the large 20-ton sleds. Its performance seemed to equal the regular LGP D4 and surpass that of the standard D4. This small tractor proved very dependable.

A total of 5000 tons of cargo, including 16,000 drums of petroleum products, were moved into Little America and the immediate vicinity during the resupply operation of 1956-1957.

The LGP D8's were well suited for handling two loaded 20-ton sleds. The LGP D4's, when fitted with fork lifts or boom and hooks, were well suited for off-loading cargo in the supply areas. The standard D4 continually bogged down in the soft, deep-rutted snow in the supply areas, and was thus ineffective. The D4 tractors that were rigged with buckets (without fork, boom, or box-hook attachments available, or that were not convertible) were extremely limited in supply use.

South Pole

Storage and locator systems were in general found to be unnecessary at the South Pole. It is accepted that all material must be within the tunnel system by March 23rd (sundown). During the summer resupply period, however, material may be left outside without danger of loss, since the Polar Plateau is not subject at that time to high winds and snowfall, as are the coastal stations. Oil drums broken on airdrop in 1956-57 and left in the drop area were still well above the surface after one year.

Air Shipment

Equipment and materials to be airdropped by C-124's had to be packaged in the Air Force A-22 containers of approximately 64 cube and 2000 pounds to satisfy parachute weight limitations. For extremely bulky loads, a platform arrangement which fits into the elevator well of the C-124 was devised by the Air Force. The maximum drop dimensions were 144 inches long, 80 inches wide and 106 inches high. A D2 tractor, drummed fuel, a weasel, and many other types of material were dropped on the platforms. Non-drop cargo was airlifted by R4D, P2V, and Otter aircraft.

Approximately 16 percent of the fuel airdropped at the Byrd Station in February 1957 was lost because of parachute failure. Eight naval personnel lost half of their clothing due to a chute not collapsing in a moderate wind. Airdrops from October through December 1957 were more successful. These drops consisted of 1385 barrels of POL, a small amount of mail, 10,600 pounds of food, and scientific construction material. Loss from these drops were very slight, but 11 barrels broke on impact out of a total of 33 drops. Other supplies were airlifted by ski-equipped R4D aircraft.

In January 25,500 pounds of food were flown in. Most of the wintering-over personnel arrived by airlift. All airdrops were retrieved with a D8 using a boom. Airlift cargo was handled by hand and loaded on one-ton sleds.

Forty-two C-124 flights were made to the South Pole prior to the departure of Deep Freeze I personnel. Each flight carried approximately 23,000 pounds of payload. In addition to the C-124 flights, the aircraft

of VX-6 made many flights to the Pole, landing there to deliver personnell and nondroppable material. The flights were coordinated in such a manner that aircraft delivering nondroppable material would evacuate construction personnel.

The cargo capacity of the R4D aircraft was limited by altitude and distance to about 2000 pounds. The P2V aircraft had greater high-altitude performance and could carry greater loads farther. It was used as much as possible during the later stages; however, due to ski landing-gear failures, it was eventually removed from operation.

Drop zone control is most essential in deep snow areas. The task of retrieving material is burdensome at all times, but is more time-consuming when the material is scattered over a large area. One attempt to drop "blind" resulted in scattering material over 12 square miles. However, most of the drops were accurate, the majority landing within 600 yards of camp. To assure greater accuracy of airdrops at the Pole Station, where manpower and equipment were severely limited, a drop-zone controller accompanied the construction personnel. The controller not only directed the drops from the ground, but also determined many causes for the high percentage of drop failures in the early stages of the operation.

The general drop procedure was to give the planes a large drop area marked by a "timing point" and a "DZ" (drop zone), which amounts to a bull's-eye. The landing strip was the timing point and the DZ was marked on the snow by long strips of Day-Glo cloth. The DZ was approximately 400 yards grid south of camp. Most drop runs were made from grid west to grid east to insure that any streamers would not fall on the camp. With prevailing easterly winds, the pilots preferred to drop flying into the wind. Normally, the pilots could and would drop any time the DZ and camp were visible from the air.

Recommendations

1. Equipment should be operationally checked prior to shipment, since working time in the antarctic is at a premium. Major defects which might be prohibitive to correct on the ice could be picked up and righted in the States, where a relative abundance of materials and test equipment are available.

2. Copies of the packing invoices describing in detail the contents of each box should be sent to each base. The boxes should be numbered for identification, and a brief description of the contents should be written on them in the event that the lists do not arrive in time or that lists attached to the boxes are lost.

3. Notification of any changes, additions, or subtractions of material ordered by antarctic activities should be sent to them so that it will be possible to have accurate planning information at all times as well as a means of checking the receipt of material ordered. All material should continue to be segregated, marked, and shipped in distinct categories determined by ultimate departmental use. This was done for most of the equipment in Deep Freeze II and proved highly successful; items not handled in this manner were not always fully utilized.

4. The maximum specifications for export packing appear necessary for cargo destined for use in the antarctic. No cardboard boxes should be sent with electronics materials. Boxes should be fitted with runners to enable fork-lift fingers to get under them. This container could be easily rigged for parachute drop; simple harness is all that is needed. Approximately one ton would be the ideal size for the G-12 cargo parachute.

5. A complete set of applicable standard stock catalogues should be available at each station.

6. A central agency should provide consumables, assign priorities, and issue shipping permits.

7. Buildings for covered storage are mandatory at a base like McMurdo.

8. Material such as drummed POL which is to be stored outside should be placed on hill ridges or relatively high flat areas where the wind can blow most of the snow away. Also, the material should not be stacked, so that if the area does drift over, the depth of the drift will not be more than the height of one box or barrel.

9. Box markings should be standardized and should be on the top corners. Category letters should be a minimum of 3 or 4 inches in size.

10. Disbursing records should leave with the individual and be carried by the pilot of the plane. Credit limits are a most important factor. During Deep Freeze II the credit limit system was well fouled up by late changes of policy; as a result, the $30 and $60 limit for enlisted men and officers, respectively, was used. It is felt that this cut down materially on ship's stores sales.

11. Number-one priority on a FAIRTRANS list should be reserved for only materials and personnel requested by the bases.

("Packaging: Subsequent years experience developed a procedure of master containers for McMurdo (about 1-1/2 to 2 tons), and smaller boxes of 300 to 500 pounds for inland stations. All boxes are skid mounted. Equipment check-out: ComCBlant insists on this, but the prospective wintering groups usually can't be bothered. Packing invoices: The supply office received packing tickets sorted by box numbers, category, and stock number. Also, he gets a sepia for every item, showing shipping

permit number and box number. All items are export-packed on an assembly line at Davisville. ComCBlant acts as a central agency. A disbursing officer is now available at McMurdo."12)

SITE RECONNAISSANCE AND SELECTION

McMurdo

Basic Considerations

A primary consideration in the establishment of McMurdo was that little data was available on which plans could be formulated. It was recognized that the utmost ingenuity and cooperation would be required from all parties concerned to meet the various exigencies as they developed. The records of Scott's and Shackelton's expeditions and the visit during Highjump and the Second Antarctic Development Project were basic data upon which concepts were developed. Basic concepts and ideas derived from previous endeavors in the antarctic were weighed in the light of many different considerations present in Operation Deep Freeze I: scope of operations, new equipment available, availability of air support, etc.

The primary mission of the Advanced Survey Party was to find a suitable site for the construction of the main camp, capable of supporting major air operations in the establishment of the Beardmore Auxiliary Air Base in the vicinity of the Beardmore Glacier and the South Pole Station. A peak population of 170 was anticipated by late 1956.

"Basic considerations such as accessibility, planned air operations, proximity to runway locations, stability of bay ice, etc., had actually more bearing on the choice of site than did the physical features of the site. There were only two possible sites for the location of the camp: Cape Evans to the north, and Hut Point. Cape Evans proved to be of limited size, and the accessibility disappeared with the bay ice about the middle of January. Once the site was established definitely at Hut Point, the problem then was to find the most suitable area at Hut Point. We chose the area promising most stable permafrost-free ground as established by test holes dug by hand and by blasting."5

Very closely related to the choice of a site for the facility was the choice of a suitable site for a sea-ice runway, anchorage for two YOG's used for the storage of avgas, and a possible compacted-snow runway in the same vicinity. All of these factors had to be interrelated in order to achieve efficient, economical operations, and to conduct those operations within the time schedule allowed. In addition, it was desired to find a suitable sea-ice runway capable of supporting planes of the Advanced Aviation Party, scheduled to fly into McMurdo in December 1955. This would be prior to the arrival of the ships of the main task force. The fly-in of other than ski-equipped planes depended primarily upon whether a suitable runway could be found and prepared by the limited personnel and equipment available at that time.

Planning Assumptions

The following assumptions were made for planning purposes:

1. Upon arrival of the Advanced Survey Party at McMurdo Sound about 15 December 1955, the sea ice in the sound would not have gone out or broken up and the edge of the ice might extend as far north as Cape Evans, if not farther.

2. The most suitable site for a sea-ice runway for continued air operations lasting into February of any year would be as far south in the Sound as possible, and the most likely runway that could stay in throughout the summer would be located in the vicinity of Cape Armitage.

3. The most likely spot for a compacted-snow runway would be on the Ice Barrier south of Cape Armitage.

4. Temperatures at Cape Armitage, being cooler, would allow better trafficability on ice and snow runways.

On the basis of the above, it seemed likely that Cape Armitage might be the most suitable area for the naval air facility. It was evident that off-loading and transportation would entail, in the early stages, transfer of material over sea ice from at least Cape Evans to Cape Armitage, a distance of about 15 miles. As the season progressed, and as the sea ice went out, this distance would decrease. It was possible that icebreakers could materially assist in reducing this distance.

Site Selected

Reconnaissance parties surveyed the McMurdo Sound area as soon as possible after reaching the area. Primarily, helicopters were used for the transportation of the reconnaissance parties. Dog teams were prepared to assist ground reconnaissance parties as required.

The site selected for the construction of the permanent naval air facility lies approximately 1/2 mile east of Hut Point and Cape Armitage, at the southern extremity of Ross Island. The site is a relatively level shelf on the volcanic rubble of Cape Armitage, 125 feet above sea level. To the west and south, the site is exposed to winds, but to the east, the direction from which most of the wind comes, the hills afford partial protection. During the summer most of the immediate camp area is free of snow; in winter considerable snow accumulates particularly in the lee of buildings, piles of stores, and other elevations above the surface. The surface of the earth is volcanic rubble from which, during the summer months, considerable dust is raised by vehicular operations. The rubble is loose for a depth of about a foot, at which level permafrost is present.

The permafrost is virtually impossible to dig or blast, and nothing more than very superficial ditching and grading is possible. The porosity of the upper level permits considerable run-off of melt water and liquid wastes along the top of the permafrost but below the ground surface.

During the camp construction, outside air temperatures ranged from -3 F to +40 F. Usually the temperature was between -25 F and +30 F until mid-February when the average values began to fall. By 1 March, usual daily temperatures were between 10 F and 15 F. Wind velocities varied from calm to 55 knots. Actual snowfall was light. It is estimated that overcast obscured the sun 60 to 65 percent of the time. Work of the camp continued on a 24-hour-per-day basis in all weather except for a few days of actual blizzard conditions.

The primary facility required for the logistic support of the South Pole Station was a runway capable of supporting operations of C-124 aircraft. The construction of the ice runway for this operation was not completed, in spite of work throughout the winter night, until October 1956, when the actual air operations commenced. It was indeed questionable at the time if the runway could be built, as equipment breakdowns and blizzards depositing tons of snow limited construction capabilities.

Little America

Little American was located on the Ross Ice Shelf, two miles inward of Kainan Bay on 750 feet of ice at 140 feet above sea level. Kiel Field, the aviation facility at Little America, was located approximately 1-1/2 miles southeast of the station. A horseshoe-shaped valley, the ends of which terminate in Kainan Bay, lies approximately 1/4 mile southeast of and surrounding Little America, making air operations in the immediate vicinity impossible. It was felt that the selection of the site of Little America Station without regard to the location of an airstrip was an error caused by the pressure of off-loading ships. This resulted in a great loss of time and created many difficulties which would have been nonexistent if the site selected for the station had been the present site of Kiel Field. Little America was the only location at which an access ramp was found capable of handling the heavy tractor traffic required to climb from the bay ice to the barrier.

Byrd

The personnel for the building of the Byrd Station were selected at Little America. Four buildings, the mess hall, meteorology, powerhouse, and latrine, were transported with the available equipment. Each building was loaded on a separate sled to allow it to be spotted next to the building site. On 5 December 1956 the heavy swing, consisting of six tractors pulling two sleds each, ten cargo sleds, one messing wanigan, and one sleeping wanigan, departed for Byrd Station site. The personnel on the

train lived in the wanigan until messing and sleeping facilities were available at the base site. Then the tractor train departed and additional personnel were airlifted to complete the construction of the base.

Beardmore, Deep Freeze I

Personnel of the U. S. Naval Air Facility, McMurdo Sound, constructed and operated the Beardmore Auxiliary Air Base. The purpose of the base was to act as an emergency refueling base for R4D's or other ski-equipped aircraft returning from South Pole flights. Its communication facilities were used as a radio relay point between the South Pole and McMurdo. The weather reports from this station were thought to be extremely significant in forecasting weather at the South Pole Station and weather approaching McMurdo and Little America. Further, the station was to be utilized as an advanced base from which to stage search and rescue operations should the need arise.

An aerial reconnaissance flight was conducted by AIRDEVRON SIX, and several tentative sites were selected. The site at the foot of Liv Glacier at 84°50' south and 166°00' west was determined to be the best.

On 28 October 1956 the first of the construction party was airlifted to the site and construction was begun. Two tents and an Atwell shelter were erected. Bad weather and mechanical difficulties prohibited landing the remainder of the Beardmore group at that time. A C-124 airdropped additional supplies, drums of avgas, and assorted equipment. The drop was spread out over a mile area. The building program was completed on 30 October when a C-124 dropped a Sno-Kitten and an R4D delivered the rest of the construction party. On 31 October the base had its first official visit. The R4D returning Admiral Dufek from the South Pole landed to refuel after its historic landing. It was the first plane to land at the geographical South Pole, and the plane's personnel were the first to set foot in that area since Scott left it in January 1912.

In December the deteriorating runway and adverse weather at McMurdo made it increasingly difficult to schedule logistic flights to Beardmore. As most of the South Pole personnel flights had been accomplished, permission was requested to close down the camp until Pole flights were resumed. However, AIRDEVRON SIX agreed to render all necessary support, and the camp remained open during the slack period. When the base was secured on 23 February 1957, all equipment was placed within the Atwell in the event the station were reopened in October 1957.

Liv Station, Deep Freeze II

The construction of Liv Station was planned in July 1957. The officer and some of the men assigned to the operation had experience

at Beardmore camp the previous year. Eight R4D loads were estimated to complete the base, plus one drop of POL by a C-124. A reconnaissance mission, combined with the first cargo flight, found an ideal location for the camp. Construction of the camp was completed in a few days without difficulty, even though sub-zero temperatures prevailed. The establishment of the Liv Station was timely, and despite the R4D's planes developing engine failures due to severe weather, the operation went off very smoothly.

South Pole

As a note of caution, the data presented results from a unique operation. Future operations using this data must keep this constantly in mind. There were several basic reports (e.g., reports of Hardtop I and II) and several records of previous expeditions (e.g., Shackleton, Amundson, and Scott) which were called upon for assistance. But the problems to be met by Operation Deep Freeze I personnel in 1956-57 were to be met in different ways than by the men of earlier expeditions seeking the Pole. Every report and record had to be adjudged in this light. There was a great deal of material to draw from, but after ferreting out the usable data, in light of the newer techniques of exploration and operations, much important planning data was still missing. The conditions that were to be met at the Pole were still conjecture. No one had ever been near the South Pole in October, the planned jump-off month. Planning for operations of aircraft to the plateau (cold, altitude, and winds were primary factors) and for the logistic support of the station by air had to allow for many unknowns. The construction group had to prepare for survival with limited air support, if such should be the case, and for walking out in case the planes could not successfully evacuate the group. Before 31 October 1956 only eight men (three with Amundson's party and five with Scott's party) had set foot on the South Polar Plateau at this inaccessible spot, and these men had arrived in December and January.

The basic planning for the establishment of the South Pole Station was done by the staff of Task Force Forty-three prior to departing CONUS in November 1955. However, because of the many unknowns involved, the final planning and preparation could not be undertaken until McMurdo had been established. Based on the broad concept developed, detailed field planning and actual preparations commenced during the winter night. A second basic decision was that the South Pole Station would have to be built in 60 days or less. The rate of construction depended on the winds, temperature, effects of altitude, rate of delivery of materials, and extent of material-retrieving operations. It was estimated that the Air Force would be able to deliver approximately 20 tons of payload per day (a little less than two flights with a C-124). An efficiency factor of 50 percent was assumed.

The South Pole Station depends entirely on McMurdo for logistic support. McMurdo was constructed primarily for this purpose. All material possible was delivered to McMurdo during January to March 1956, and prepared during the winter for delivery to that station. Slight changes in planning required a flexibility that prohibited all material from being prepared prior to the arrival of the Air Force aircraft in October 1956. The Air Force was responsible for delivery of the material to the South Pole Station, with the exception of men and nonair-droppable material (fragile), which was delivered by aircraft of VX-6.

Landing of the first construction personnel at the South Pole was delayed until 20 November 1956. The temperatures experienced were mild compared to the anticipated temperatures of -35 F used as a planning figure. During construction -35 F was a minimum, the average temperature being more nearly -5 F. Winds during construction were very mild, especially compared to those experienced at McMurdo on Ross Island. At no time were winds of such force as to handicap construction personnel.

Hallett

Cape Hallett Station, 72°17'40" south and 170°18'30" east, surrounded on three sides by mountains of the Victoria range, is adjacent to Moubray Bay.

Wilkes

Wilkes Station was erected in record time by Mobile Construction Battalion ONE at the chosen site on Clark Peninsula at 66°15.5' south and 110°31.2' east. Wilkes Station is located in the Windmill Islands, Vincennes Bay, off the Wilkes Coast of Antarctica.

Ellsworth

An intensive search for unloading and base sites in the vicinity of 40 degrees west longitude was made on 26 January 1957, and a tentative unloading site was chosen. At this location the Filchner Ice Shelf, the deepest indentation of the Weddell Sea, was approximately 25 feet high. Access to the top of the shelf, approximately 90 feet higher than the edge of the shelf, could be had only by means of a very steep and soft snow ramp. An attempt was made by an ice-breaker to smooth off the shelf at this location so that the cargo ship could come alongside the ice shelf to unload. The attempt was not successful. Five hundred yards to the east of the first location, the shelf was lower, approximately 18 feet high, but bounded by a considerable amount of hummocked, fast ice. The ice-breaker cleared away enough of this ice to enable the cargo ship to come alongside the shelf. The grade to the top of the shelf was more gradual and the snow appeared more compact than at the first location. The area on top of the ice shelf, which was about

115 feet high, was relatively flat, with a smooth surface and small sastrugi. A base site was chosen two miles from the unloading area on a V-shaped projection of the ice shelf.

The base site is at 77°41" south and 41°7" west. The escarpment, or shelf, is approximately 2 miles from the camp in a west, north, and easterly direction. The Antarctic Continent lies to the south. Seismograph soundings proved the ice shelf to have a thickness of 800 to 900 feet. The water beneath the shelf measured 2200 to 2500 feet in depth. Undulations in the shelf averaged one foot. The elevation of the platform which held the meteorological instruments was 137 feet. This was used as the standard elevation of the station.

During the camp construction the shop facilities and supplies of critical materials were made available by the task force ships. The ice breaker furnished working parties from the beginning of construction, and further assistance was given by the crew of the cargo ship as unloading neared completion. Without this assistance the rapid rate of construction could not have been achieved.

During this period the temperature ranged from -9 F to +24 F. The wind velocity was usually around 23 mph, with very few calm periods. Snow, accompanied by high winds, fell on four days in February.

AIR SUPPORT

Air support includes logistic support, aerial reconnaissance incident to site selection, aerial mapping, photography, transportation of personnel, search and rescue, and weather reconnaissance. Main airfields were established at McMurdo and Little America, with auxiliary skiways at Beardmore, South Pole, Byrd, Cape Hallett, and Ellsworth.

Aircraft and Personnel

Air Development Squadron Six (VX-6) was assigned primary responsibility for reconnaissance, mapping, photography, search and rescue, and intra-antarctic personnel and nondrop cargo-carrying where ski-equipped aircraft were required. Aircraft assigned included R5D wheeled P2V ski-wheeled Neptunes, R4D ski-wheeled Dakotas, UF-1 ski-wheeled Albatrosses, UC-1 ski-wheeled Otters, and HO4S wheeled helicopters. All except the Otters and helicopters were flown in from the U. S. via New Zealand. The Otters and helicopters were transported to Antarctica by ships.

From December 1956 to February 1957 the C-124's of the 52nd Troop Carrier Squadron, USAF, airdropped more than 550 tons of supplies and construction materials for the Beardmore, Byrd, and South Pole Stations, and dropped fuel for the tractor train operations to Byrd Station.

Aircraft Limitations

The R4D capabilities for heavy-load, high-altitude performance are extremely marginal. The P2V's had not proven themselves because of faulty ski-landing gear. With 14 bottles of jato, the take-offs of the R4D's from the South Pole were marginal. It was believed that with warmer temperatures during the summer months, and with improved surface by dragging, the aircraft would have had an easier time of it.

Air Operations

McMurdo

AirDevRon Six carried out the initial fly-in from New Zealand to McMurdo on 20 December 1955. Two P2V's and two R5D's arrived. The R4D's and UF's returned to New Zealand because of unfavorable head winds. The arrival of the aircraft preceded the arrival of the MCB (Special) Advanced Party at Hut Point by 24 hours. Aviation gasoline was not available to these aircraft for ten days. The only Otter in the McMurdo area at that time crashed on take-off on 22 December. Air operations were necessarily limited primarily to helicopter flights until 1 January 1956, when fuel and services became available. The most important flights, those to the geographical South Pole and photo missions, were conducted during the period 3 to 15 January 1956. The P2V's and R5D's returned to New Zealand on 18 January.

After the departure of the R5D's and P2V's, air operations up to the time the last ships departed, 9 March, consisted of Otter and helicopter flights of a local nature. Ice reconnaissance and local photographic missions were frequent. Numerous flights were conducted to Cape Evans, Cape Royds, Dry Valley, and other landmarks within the immediate area. There was no central control of air operations during this period. The helicopter and to Otters assigned to McMurdo staged out of Hut Point. The helicopters from the icebreakers operated under a shipboard "Hello Control," manned by AirDevRon Six.

Prior to the last ship's departure, the two Otters assigned to McMurdo deployed to Little America Station to assist in an SAR mission. One of the Otters was damaged while off-loading onto the barrier near Kainan Bay. The second was left at Little America because of constant bad weather between Little America and McMurdo. No attempt was made to retransfer it by ship, as the loading operation would have been extremely precarious due to the adverse conditions at the barrier's edge.

The McMurdo helicopter received extensive damage in the storm on 28 February. Following repairs, it was flown extensively during the period 28 March until 20 April 1956 on ice and photographic reconnaissance flights. Experimental airdrops of diesel fuel contained in both

rubber and metal tanks were also made. As the temperatures dropped below -20 F, at least two hours preflight was required to satisfactorily loosen flight controls and free all moving parts, cold-weather lubricants notwithstanding. VHF radio contact was effective between the base and the helicopter for approximately three miles, but due to the low altitude of most of the flights, contact beyond this range was unsuccessful. Combined GCA helicopter flights were made by prearrangement. The helicopter would fly over the northernmost ice edge in McMurdo Sound on a general east-west heading from Ross Island to the antarctic mainland. Radar maintained a constant track on their scope, which was transcribed to a map of the area. In this manner ice growth was plotted quite accurately. In addition, GCA's were also carried out to give the air-control men practice and to enable them to properly align their scopes.

From the 20th of April to mid-October, with no aircraft available for flights, the wintering-over aviation personnel at McMurdo concentrated on the installation of navigational aids and completion of aviation control and maintenance facilities, and assisted in the construction of the ice runway. During the crucial period from mid-October 1956 through January 1957, the tremendous importance of air support focused attention on McMurdo Sound. The VX-6 aircraft returned on 17 October and C-124's began arriving on 21 October. Flight operations averaged 75 long-range flights each month.

From the first flight on 17 October, it was apparent that most of the landings would be under actual GCA conditons, for the sound at McMurdo has extremely variable local weather conditions. The camp area was often clear while the runway was socked in with blowing snow up to 400 or 500 feet. At times, the runway was also fogbound. The C-124's operated around the clock as long as the South Pole or Byrd Station weather permitted them to make airdrops and return to McMurdo. Their normal refueling and servicing was accomplished within an hour and a half maximum.

By early December, continued warm weather had caused rapid deterioration of the ice runway. Severe melting had resulted in the development of extensive and dangerous potholes. This condition, coupled with the exhaustion of the aviation gasoline supply caused the C-124's to return to New Zealand to await a good cold snap which would restore the runway to a usable condition and the arrival of a tanker with the necessary gasoline. At this stage, vital material and personnel still were required at the Pole, Beardmore, and Byrd Stations.

Ski-equipped aircraft operations remained feasible at McMurdo, so that VX-6 ships lifted IGY nondroppable cargo and food to the Pole as weather permitted. Later, the squadron began the exchange of wintering-over personnel for the construction groups at the Pole and Beardmore Stations. This continued through early January, when ski failure on the

P2V aircraft and accelerated runway deterioration halted all air operations at McMurdo. Colder weather assisted in restoration of the ice runway by early February and permitted the C-124 aircraft to return and complete the airdropping of supplies. By mid-February, ski-equipped VX-6 aircraft had delivered the last wintering-over personnel to the Pole. Colder temperatures at the Pole precluded further ski landings there.

Little America

Air operations commenced at Little America on 4 January 1956 when the first reassembled UC-1 Otter became operational. A total of three UC-1's were transported to Little America aboard ships of the task force. These craft were supplemented by HO4S helicopters from the icebreakers. Throughout off-loading operations and base construction, the Otters and helicopters completed innumerable flights for local reconnaissance and transportation of personnel and supplies between the ships and the construction site.

On 9 January the first heavy, long-range aircraft arrived at Little America. A P2V landed on an unprepared snow surface to pick up personnel for an aerial reconnaissance flight into Marie Byrd Land. The fly-over of the terrain between Little America and the proposed site for the Byrd Station was preliminary to tractor train operations. Between mid-January and early February 1956 and Otter was employed in support of trail operations, transporting personnel and supplies and flying short-range reconnaissance.

During the first week of February Little America became the base for the first search and rescue operation when an Otter failed to return from a trail support mission. The downed aircraft was eventually located and all aboard returned safely to Little America.

Flight operations were resumed in October 1956 utilizing ski-equipped R4D transport-type aircraft and Canadian UC-1 Otter aircraft in support of tractor train operations, Byrd Station, Beardmore Glacier Station, IGY traverse parties, an ice deformation party, personnel transfer, and general reconnaissance purposes. Extensive flight operations were conducted during the summer months, with very limited flight operations during the winter due to extreme low temperatures and adverse weather conditions. Helicopter operations were deemed practical for summer only.

Hallett

Air operations at Hallett were held to a minimum because of ice conditions and limited personnel and equipment. During the wintering-over period only five aircraft landings and take-offs were made, the first on 1 November 1957 and the last on 23 December 1957. All of these operations were conducted with R4D-type aircraft.

Wilkes

No air operations were conducted from this station, except for aircraft operating from ships during the short summer resupply period.

Ellsworth

The snow cover in the vicinity of the base was smooth with very gradual grades. It was usable as an airstrip in its initial stage. VX-6 personnel marked out an airstrip adjacent to the camp by placing flag markers at 100 feet on centers.

Support Facilities

McMurdo

Between 20 December 1955 and 15 January 1956 large-scale air operations were impossible because the aircraft arrived before the navigational aids, airfield equipment, material, and petroleum products. Aviation gasoline itself was not available for 10 days.

The control tower was set up on the south side of the runway. Both the tower and GCA (Quadradar) were mounted on a 20-ton sled. The tower was very small and cramped (8 feet square). At first all power for the tower and GCA equipment was supplied by a 30-kw single-phase diesel generator except for communications when 28 volts was supplied by a motor-generator set or batteries. With this system long-range communications were limited. About 1 February two 10-kw three-phase gasoline-engine generators were installed along with a rectodyne for communications. This proved much more satisfactory than operating with the limited power of the batteries and the noise of the motor-generator set.

A new tower building was constructed in July 1957 on a 20-ton sled. It contained three rooms, a tower room with windows on three sides facing the runway, a radar room in the middle, and a bunkroom, which contained two bunks and some messing facilities, on the other end. These facilities later proved useful on several occasions when men were stranded at the runway during blizzards. The following equipment was installed in the tower: Two AN/ARG-1, one AN/ARR-15, one AN/ART-13, two AN/ARC-2, one TED-6, one URR-35, one BC-348Q, one RD-115/UN, one URD-2A, one ID-300A/UMQ, a wind direction and velocity indicator, two light guns, one rectodyne power supply, one TPS-1D radar (no power supply to operate) and batteries and a battery charger. A GCA antenna mount was installed on a 20-ton sled, and the alignment of the radar was completed at the GCA building in camp. Tower and GCA equipment were moved to the runway late in August. The equipment was aligned and flight was checked and readied for operation at that time.

Enroute control of aircraft was handled primarily by a VX-6 air-operations duty officer. However, many times the tower was given control of aircraft due to difficulties in the equipment at air operations. As air operations had only one transmitter, the tower sometimes had to control aircraft flying within Antarctica when air operations was controlling traffic to and from New Zealand.

Initially there were two 5000-gallon Air Force trailer-type refuelers at McMurdo. By October 1957, their second year of operation without new parts and proper maintenance, only one was in commission for most of the October-November air operations. A 2000-gallon refueler was used to refuel the ski-equipped aircraft.

Servicing aircraft with lube oil was a frustrating procedure. About ten 55-gallon oil drums were kept in a heated wanigan. A drum had to be inside about two days prior to use. When required, the oil was poured into 5-gallon cans, which were manhandled up to the engines and poured in manually. This system was a cold, slow, dirty, and difficult job.

Little America

The buildings of Kiel Field were erected equidistant from the ends of the skiway and 400 feet to the northwest. The location was most favorable to efficient operation of the GCA and to observation of aircraft from the control tower. The first building to be erected was the homer shack, an integral part of the URN-5 radio beacon. It was selected as the first building to be erected because of its importance as a navigational aid to the aircraft providing support for the 1955-56 tractor train reconnaissance party. After an Otter crashed on a return trip from the trail party, the Quad GCA and VHF and HF communications were temporarily installed for search and rescue use. They were housed in a 10-man tent mounted on a 20-ton bobsled.

At the end of SAR operations, construction of the Deep Freeze type buildings was commenced. The buildings were placed end to end and 20 feet apart. An 8-foot by 8-foot by 8-foot control tower, with double plexiglass windows on all sides, prefabricated from Clements panels at Davisville, was erected atop the north corner of the electronics building. A trap door was cut through the roof of the building for access to the tower. This also allowed heat to circulate into the tower from the building. The windows frosted up between the two sheets of plexiglass. This condition was corrected by removing the inside sheet, sealing the outside one, thawing and drying both sections, placing a 1-inch layer of dessicant at the bottom between the two sheets, and resealing the inside sheet.

GCA indicator units (Quadradar and Spar), VHF/DF indicators, air-traffic control light, and a complete communications remote-control

system were installed in the tower. The GCA and VHF/DF indicators and the operator's position were enclosed by black curtains. A tunnel enclosing the area between the electronics and maintenance buildings was constructed from timbers and plywood to house two 30-kw generators, two 28-v motor generators, one 28-v selenium rectifier, a gasoline-driven air compressor, a Herman Nelson preheater, and two battery chargers.

Aviation gasoline, oil, oxygen, jato, auxiliary power units, and fire and crash equipment were available at Kiel Field. The fire and crash equipment consisted of a fire-fighting sled housing a 500-pound Ansul extinguisher and was towed by a weasel or Sno-Cat. This equipment was manned and ready during all take-offs and landings. No hangar facilities were available; however, limited indoor maintenance and repair shops were available for minor aircraft repairs.

Aviation gasoline was stored in a 100,000-gallon tank located adjacent to and southeast of the main station. Fuel from this tank was pumped into small 800-gallon tanks mounted aboard an Otaco sled. A D8 was used to shuttle this sled to and from the Kiel Field refueling area, where the fuel was pumped into a 3200-gallon refueler and a 10,000-gallon rubber storage tank. Utilization of the 10,000-gallon rubber tank made it possible to have fuel available and readily accessible even during the periods of heaviest flight operations.

Byrd

No aircraft repair facilities were available at Byrd Station, other than that which individual plane crew equipment and capabilities permitted. Preheaters were on hand, but no covered working spaces. Prior to the October 1957 airdrop, no fuel or fueling facilities were available. Each aircraft was required to carry sufficient fuel and jato for the return trip. Upon commencement of October airdrops, both fuel and jato bottles became available, and with a Barnes portable 50-gpm pump, aircraft refueling in the parking area alongside the runway became fast and efficient.

South Pole

Maintenance facilities for aircraft were extremely limited. When the P2V-7 lost an engine while warming up for take-off (late October 1957), a line shack was constructed from damaged building panels, with a floor area of 8 feet by 12 feet. A stove was installed which permitted the mechanics to warm up periodically and provided warm storage for the prime movers for the Herman Nelson heaters. The facilities of the garage were available, but were limited. No aircraft parts or POL products, other than avgas, were available at the Pole, except as specifically ordered and delivered. Only a limited amount of drummed avgas was available. Aircraft were given additional gas where necessary, fueling being done simply with a standard drum pump.

Hallett

No aviation personnel or maintenance facilities were available at Hallett Station. Only a limited amount of aircraft fuel and jato units were available. During the wintering-over period only one of the five aircraft landing at Hallett required fuel. This fuel was hand-pumped to the aircraft to replace fuel that had been used in engine run-ups when the aircraft remained at Hallett Station overnight and no Herman Nelson heaters were available.

Airstrips

McMurdo

The ice runway was still in the process of being cut with the arrival of the first aircraft in October 1956. No time had been available to smooth the top surface. The runway proper was marked along the sides with red flags at intervals of 75 feet. The approach end and sides of the runway were marked with Day-Glo strips. Day-Glo strips also marked the approach to the runway by indicating the number of feet in thousands remaining; i.e., 4, 3, 2, and 1. These were white numerals on a black background of 8-foot by 10-foot canvas stretched between bamboo poles. When the supply of Day-Glo strips was exhausted, empty diesel drums were inverted and placed in the snow in a straight line on an extension of the runway center line. At the end of the runway the barrels were placed in the form of the head of an arrow some 40 feet from the actual approach end of the runway. Barrels recessed flush with snow, tops exposed at all times, indicated the beginning of the runway proper. The Day-Glo strips were definitely superior to oil drums. However, snow tended to cover the strips, necessitating daily cleaning. Excessively strong winds caused a comparatively short lifespan, and replacement was required about every 21 days during summer operations.

Three hundred yards to the north side of the ice runway, and east of the fuel farm, a snow skiway was prepared for the ski-equipped aircraft. Direct field-phone connections were made between the control tower and the air operations building. This building was located within the camp itself. The aerology office was complete and well equipped for observations and limited forecasting, but the location of the office on hilly terrain a mile and a half from the airstrip caused erroneous readings on all surface and upper air observations. Future operations should try for a better location if possible.

An emergency strip was prepared to afford an alternate landing spot in the event the main ice runway was closed for any other reason. This strip was located five miles northwest of Hut Point on the ice which had formed during the preceding winter night. The cleared surface of 6000 feet was somewhat smoother than the actual ice runway. The ice depth

averaged 73 inches and was satisfactory for emergency operations. However, large aircraft, such as the C-124, would be unable to remain in a parked position longer than a few hours. In December the ice underwent rapid deterioration, losing as much as 7 inches of depth in one week. By late January this entire area had gone to sea. While it was maintained and marked all during the period 15 October to 1 January, the only traffic was light planes shooting "touch-and-go" landings.

Little America

The Little America air facility was located 1.2 miles southeast of the main base, at an elevation of 125 feet above sea level. A study of the prevailing winds at previous Little America camps revealed that they were from the southwest. This coincided with the direction of the sastrugi at Little America V. The skiway was laid out paralleling the sastrugi, with the northeast end approximately 300 feet from the beginning of the gradual descent into the valley.

The skiway was 6000 feet long and 300 feet wide, with a 2000-foot overrun on the end. For Deep Freeze I, it was marked at 200-foot intervals with 9-inch-square red trail flags mounted on 4-1/2-foot bamboo poles. The corners were marked with 2-foot-square red flags on 10-foot bamboo poles. No surface treatment was necessary during the summer months. However, with the coming of fall and increasing bad weather, the skiway became too rough for flight operations. A narrow strip 100 feet by 3000 feet was maintained by blading with a D8 tractor until July, when the Otter was irreparably damaged in a windstorm. From July to October no work was done on the skiway. In October, work was resumed in preparation for the arrival of the aircraft for the summer season. Six thousand feet were prepared. The flags outlining the original skiway were very hard to see. Taxi strip and runway reflectors, Type B-1, Specification MIL-R-7264, were substituted. Turned inside out to present a dark blue surface, they were mounted two to a pole at 90 degrees to each other for maximum visibility. These were spaced at intervals of 100 feet. The badly faded the blue surface of the markers. The corners of the skiway were marked with oil drums.

For Deep Freeze II and III, the skiway was marked every 100 feet with bright orange markers mounted on wooden stakes extending approximately 3 feet above the surface. There were ten oil drums marking the extended center line of skiway 33, which was the ground-controlled approach runway due to prevailing wings, the runway most generally used for operations. The skiways were capable of handling ski-equipped aircraft only. The runway was continually bladed by D8's or a snow planer in order to keep it in peak operating condition.

Taxiways were 50 feet wide and marked every 200 feet by red flags on bamboo ploes. The aircraft parking area was located between the operations buildings and the skiway. The aircraft refueler and tiedowns were also located in this area.

Beardmore

A Sno-Kitten was used to pull a drag and smooth an area suitable for ski-equipped aircraft to land. The area was marked with trail flags.

South Pole

The skiway was oriented approximately grid north and south to conform to the more predominant pattern of sastrugi. It was two miles long and 75 feet to 100 feet wide. A 5000-foot strip was parallel to this strip and 300 feet to grid west. The parallel strips permitted one P2V and two R4D's to operate at the same time, as it was the practice for those craft to fly the route simultaneously to cover one another. Tractor-drawn drags were used to knock down the sastrugi and level and compact the strips. The strips were marked along the sides with red flags every 300 feet. The ends were marked by strips of Day-Glo. The approach zone was indicated by long rows of barrels, starting a mile out, parallel to the sides and center lines.

Several landings were extremely marginal due to ice fog, and a weasel was therefore parked by the touchdown point to give pilots some perspective. As the camp increased in size, the radar capabilities of the aircraft increased so that the station was eventually picked up from 40 miles away. On 1 November 1956, an R4D found the granular unworked snow tough to taxi on and froze fast after 49 minutes on the ground. The temperature was -58 F.

Hallett

The Hallett runway was located on the ice of Moubray Bay approximately six miles from the main base to allow maximum usage when ice conditions deteriorated. The runway was layed out in early October as an emergency landing facility for aircraft flying between New Zealand and McMurdo. This runway was two miles long and 300 feet wide. It was marked on both sides with trail flags every 150 feet and empty oil drums every 300 feet. At the one-mile marker, one oil drum and one large flag were offset on either side; at the two-mile mark, two drums and two large flags were offset. An area approximately one mile long was allowed for overrun. The approach end of this runway was indicated by offsetting barrels at a 45-degree angle on either side of the runway.

Another navigational aid was installed at the recommendation of VX-6 pilots. This consisted of a large arrow made of discarded oil drums mounted on the bay ice directly in front of the main camp and pointing to the runway. A line of barrels spaced every eighth of a mile connected this arrow with the approach end of the runway. This barrel system of lining the runway is not considered the best, because of the possibility of aircraft striking the barrel.

Recommendations

The support of the Pole Station as well as Beardmore and Byrd Stations depends on the runway condition at McMurdo. This runway was built on sea ice, which is unpredictable. An earth landing strip should be constructed if operations of a more permanent nature are planned. Thus far, no suitable site has been definitely found, but efforts should be continued in this direction. "The Construction Battalion Reconnaissance Unit did a feasibility study for a permanent-type airstrip at Marble Point, about 40 miles from the present McMurdo Station, during Deep Freeze III and found it to be feasible from an engineering standpoint."[12] If wheeled aircraft could be landed at the Pole and Byrd Stations, the support of those stations could be easily accomplished. The construction of a compacted-snow strip at the Pole should be investigated, as the maximum temperatures there are approximately zero Fahrenheit.

SECURITY AND SAFETY

McMurdo

Safety Program

The proper safety training and observance of this training is extremely important in the antarctic. In spite of frequent informal and formal safety training, McMurdo's accident rate was very high. As far as possible, steps were taken to make people cognizant of the hazards, but the total danger can never be eliminated. Prior to deployment, lectures were given by the medical officers at Davisville to both summer support and wintering-over personnel. These lectures included first-aid of various injuries that might be sustained, and even included lectures on preventive medicine—for example, venereal disease, frostbite, and snow blindness. Informal discussions were conducted at McMurdo with individuals concerned. Further safety precautions were promulgated to specific individual personnel. A safety officer conducted an excellent safety program which emphasized the need for careful observance of safety rules and regulations and pointed out possible hazards on the ice to be guarded against. In addition, local instructions, both formal and informal were published, as needed. All possible hazards to safety were eliminated or lessened.

Safety Hazards and Precautions

There is no question that McMurdo should be considered a hazardous isolated duty station, especially in view of: (1) the hilly, icy terrain; (2) the winter darkness; (3) severe storms with high winds frequently obscuring visibility; and (4) the necessity of wearing clothing that limits visibility and agility. Of the 87 winter personnel at McMurdo during Deep Freeze II, 15 had at least one plaster cast during the year, one death occurred, and numerous other injuries, such as burns and minor frostbite, were sustained. One must caution people to be alert at all times. Avoidance of unnecessary dangers is imperative. A sense of looking out for one's self and one's fellow man is necessary.

Cold-Weather Hazard. McMurdo is an outdoor base. Buildings are not interconnected by tunnels, consequently men are subjected to the elements, resulting in impaired dexterity due to bulky clothing and the cold. In the summertime, in spite of all precautions, weasels and other forms of transportation traveling on the bay ice can suddenly break through into the cold antarctic water. Snow blindness is a hazard, causing the wearing of dark glasses to be a necessity. Carbon monoxide poisoning can occur. Much diligence and caution have to be observed in all areas, depending on whether one is crossing crevasses, climbing mountains, or on a trail party.

Personnel were instructed in regard to certain basic precautions to observe when going out into the antarctic winter, such as wearing proper clothing and wearing goggles in storms, even when going to an adjacent building. Very little can be done about the hilly terrain and ice around McMurdo. Railings were installed on head steps. Extremely icy areas were announced to the camp along with the daily morning temperature and wind velocity, enabling personnel to dress appropriately. Icy areas, such as occurred from drainage of water from the shower and laundry facilities at the powerhouse were periodically broken by heavy machinery such as D8's to enable one to walk over the area more safely.

Most of the weasels had the cabs removed. This was practical in most instances, for personnel were dressed for the weather, and certainly should a weasel go through the ice, the chances of escape are much better. On a long trail party, closed vehicles would be preferred. But in and around camp, the open vehicle is less apt to result in injuries because it allows greater range of visibility and a more ready means of escape. Personnel were instructed to stay on well-tested and -marked ice roads.

Carbon monoxide hazards were eliminated as much as possible. All personnel were made cognizant of its danger and warning signs. The carbon monoxide warning system installed in barracks at McMurdo was extremely sensitive and not very practical since the alarm rang for cigarette smoke.

Storm Hazards. Blizzards affecting visibility and with high winds were unpredictable. All hands were required to check out with the OOD any time they left the immediate camp area. They were also urged to use the "buddy" system. Each chief was made responsible for tying down the loose gear around his working area or storage space. Plywood, sheet metal, boxes, etc., made dangerous projectiles in 80 or 90 mph winds.

A storm bill was published and explained to all hands early in the year, well in advance of the first blizzard. In brief, there were three storm conditions:

Condition II - Good weather, visibility 2 to 3 miles or more, and light winds.

Condition I - Poor weather and getting worse, visibility 2 miles down to 1/4 mile. No restriction on personnel movement within central portion of camp or on groups going to outlying buildings or working areas. Persons moving singly out of the central camp area had to have permission from the OOD/JOOD, and give departure time, ETA, and report arrival at destination via the intercommunication system.

Condition Zero - Visibility less than 1/4 mile, usually caused by blowing snow with winds in excess of 25 mph. Groups could sometimes check

out for outlying building areas, but gave their departure time, ETA, and arrival report to the OOD/JOOD via the intercommunication system. Within the central portion of the camp, only those persons moving singly between buildings reported their movements to the OOD desk.

Excellent cooperation was given by everyone, for it took very little imagination to visualize what could happen during a blizzard. Blizzard and near blizzard conditions developed so rapidly that only the personnel safety aspect of the standard Navy storm bill was ever able to be placed into effect. During normal conditions there was a constant effort to tie down or store material and equipment susceptible to being blown away or buried. The camp diesel tanks were refilled when they were about half empty. Manila lines were strung from a central camp building to each of the outer camp buildings where personnel were on watch 24 hours a day.

Restricted Areas. The hazardous areas were listed as restricted to all personnel, except those on authorized work details, and published and explained verbally to all hands. In the same directive were listed shrines and monuments of former expeditions, and all the territory outside the camp, runway, and the road between the two. A party of two or more persons was allowed to go hiking to undangerous areas if they were checked out with the OOD/JOOD. Upon checkout, the OOD would review the danger areas, check aerology for a favorable weather forecast, and log the party's destination and ETA. This procedure proved to be an excellent control 95 percent of the time and broke down only when the ships granted liberty to large shore parties.

Fire Hazards. Fire is an ever-present danger in the antarctic. All hands were constantly cautioned concerning fire hazards. Practice drills were held periodically. An additional fire watch was established which required walking about 1-1/4 miles around camp, and checking essential buildings every half-hour that were not entirely maintained on a 24-hour basis during the midwinter night. These watches, of course, had to be eliminated or reduced when severe storms dangerously obscured visibility. Another feature connected with safety consists of not wearing fuel-drenched or oil-covered clothing, particularly by mechanics or personnel who are engaged in welding.

Work Hazards. Certain types of work are much more hazardous than others. Examples are barrel rolling and construction in open areas during both winter and summer. Several accidents occurred when rolling barrels in spite of all precautions because the only effective way of rolling the drums was by hand. Desterity is limited by gloves and one cannot touch cold metal with bare hands as they freeze to the object. Visibility is further obscured by currently designed cold-weather clothing. Avoidance of fatigue is important. As much as possible, the long hours put in by

all personnel, summer and winter, should be reduced. This was often not possible, however, because of a shortage of personnel.

Flying Hazards. With regard to aircraft safety measures, basic rules of safety apply. Depth perception can certainly be in error, either in the direct sunlight on the snow, or when night adaptation has been ruined by landing lights. The wearing of contact gloves inside heavier gloves or mittens is important for flying personnel. The most severe burns sustained by the occupants of a helicopter which crashed occurred on the hands of a person who had to remove his mittens to unbuckle his safety belt with his bare hands. Safety belts should obviously be worn on all take-off's and landings, and also for low-altitude flying in the helicopter and Otter, except to perform necessary functions. Helmets should also be worn in these aircraft.

Little America

Camp Security

During nonworking hours a Fire and Security Watch made a complete tour of all Little America spaces each half-hour. During storm conditions, additional fire and security watch personnel were appointed in order to have a continual patrol. Buildings were inspected for fire hazards, stress and strain from storms and other unnatural conditions, and the carbon-monoxide detectors were inspected for operational status and carbon-monoxide content. The malfunction of equipment and systems under conditions of use in the antarctic was unpredictable. In order to ensure and expedite corrective action where necessary, a duty watch stander was appointed in each applicable rate. All petty officers were eligible for this watch and were on call for a 24-hour period. Typical equipment checks were made by departments concerned on stoves and the heating system, generators, the water system, and the fire-fighting system.

Safety Hazards and Precautions

Fatigability hampered most personnel upon first arrival to the ice. This condition persisted generally for one to three months. Many factors were responsible for this initially, yet it was inexplicable after six to eight weeks. With the maximum outdoor workload of the summertime, the factor of personnel fatigue was a serious threat to safety. Everything proceeded at breakneck pace in the race with the sunlight and frozen seas. Cold working conditions imposed a greater demand upon available personnel, thereby increasing the number required to perform a given task.

Accident prevention was stressed throughout the year. Constant awareness of routine industrial safety procedures was a laudable achievement of the seabee crew. The high level of general competence was reflected

in these practices. Ventilation of snow-covered buildings, especially sleeping quarters, was checked regularly. Blower fans in each building evacuated air into the main tunnel. A continuous flow seeped in from the opposite side of the hut, under cracks. Carbon monoxide detectors were present in most buildings. Whatever levels of CO that were produced by the crude diesel oil did not present a hazard. On occasion, however, an extra access to outside air was installed by putting a stovepipe through the roof. The few cases of CO intoxication which did occur were as a result of gasoline engines used in garage spaces. All cases were mild and of short exposure times.

In an effort to explain the persistent slight occurrence of troublesome headache, a light-meter survey was conducted during the winter night. This was particularly important at Little America because of the complete dependence upon artificial lighting during four winter months, and for a longer period of outdoor daylight which, because of the drifted snow cover, was not available within the camp. The results showed a uniform deficiency in this respect.

South Pole

Lack of large quantities of unfrozen water, dryness of atmosphere and usual fanning winds are primary reasons for a constant program of prevention against fires. Once a fire gets started there is very little that can be done. Fire extinguishers must be placed about to stop fires before they get well started. The 20-pound and 150-pound Ansul fire extinguishers were not considered effective pieces of equipment under the circumstances encountered. "Ansul is not supposed to be effective against Class A fires, although in one case my unit used it to advantage to put out a Jamesway fire. Ansul's prime use in Antarctica is for fuel fires."[12] No piece of fighting equipment can take the place of diligence on the part of every man.

In order to increase the protection against fire, a fire wall was placed grid east of the powerhouse and garage between the barracks Jamesway and the garage. Fire-fighting stations were located at the two entrances in the fire wall. If a fire should wipe out half the camp, the other half could survive until spring with sufficient, though naturally reduced, fare. The survival Jamesway could be used if the entire camp were destroyed. Located 200 feet grid south of the main buildings, it was stocked with sufficient supplies and equipment to allow 18 men to survive for six months.

The basic concepts of fire fighting at the Pole Station were as follows: (1) prevention of and stopping any fire before it got out of control by having many hand extinguishers in all areas; (2) if a fire should get out of control, keeping it confined to one portion of the camp. In case of a serious fire, personnel would concentrate on stopping

it at the opening of the two tunnels into the fire wall. Two 150-pound Ansul dry powder nitrogen-actuated units were located at these two points. It was recognized that the scientific program would be severely handicapped if a portion of the camp should burn down, but survival of the men was assured. Fire axes, OBA's, safety lines, fire blankets, and asbestos gloves were available. All Walter Kiddie extinguishers were filled with a solution containing an additive to prevent freezing, even though the units were located indoors where it was warm.

Byrd

A fire and generator watch was established after the generators were put in service. The duty rotated among all hands, excluding the cook and radioman. With the increased outside activity associated with station construction and airdrops, this rotation was suspended and the duty was assigned to the duty radioman who received assistance from the night aerologist. The duty consisted of half-hour inspections of all heated buildings. An electric fire-alarm system had alarms mounted in each heated building, connecting into a central indicator panel. Two carbon monoxide alarm systems were eventually found and installed, one in each of the berthing buildings. Both alarms were found damaged, and required repair.

Hallett

The security of the station during working hours was assigned to the personnel in their designated working spaces. During the night a base security and fire watch was assigned to the duty aerographer, who made periodic rounds of all buildings and huts. As aerology was located in the mess-hall building, the duty aerographer also maintained a watch on the master fire alarm. In the event of a major disaster to the station, an emergency cache was provided a half mile from the main base. This cache was provisioned with enough food, fuel, clothing, building materials, and medical supplies for the entire camp to exist for approximately six weeks.

Wilkes

The temporary camp of Jamesway huts, erected to house the summer construction personnel, was left intact after their departure. Food, clothing, and POL for survival of the station complement was stored in and near this area, which is located approximately 800 feet from the main base area. A 30-kw generator and a Navy model MM semiportable radio were also stored there.

A continuous security watch was maintained, rounds of the base being made every hour from 0800 to 1700 and every 30 minutes during the rest

of the day. The duties of the watch included fire protection, generator checks, storm damage detection, and carbon monoxide detection, as well as checking for any other unusual occurrences. During storms the duty radioman was responsible for accounting for the security watch to assure that he returned from each round.

Ellsworth

Accident prevention was stressed by signs and talks. Signs reading "Caution Icy" were placed in appropriate spots. The responsibility of keeping the steps to buildings and the main tunnel free of snow and ice was assigned to individuals and checked on regularly. Notices were posted concerning the use of dark glasses and warning personnel not to leave the station site without permission. Occupational hazards, such as power tools and circular saws, were inspection for shielding. Operators of power drills and welding equipment were provided with safety goggles. A fire watch was maintained from 2200 to 0800. It was the watch's duty to see that a complete tour of all buildings on the station was made every half hour. Besides the hazard of fire, the watch was also alert for carbon-monoxide fumes. The OOD made periodic checks on the fire watch standers, and instructed them as necessary in order to insure maximum fire protection.

Section II

WEATHER AND GROUND CONDITIONS

GENERAL CONDITIONS

Operations in the antarctic, while differing in character from operations in a more temperate climate, depend upon the same fundamental factors—weather and ground conditions. Adverse weather and ground conditions generally affect all phases of operations—air, ground and sea.

In planning for Deep Freeze I, the records of previous expeditions to the antarctic and sub-polar regions were used as guidelines. These records generally contained information from scattered locations and over relatively short periods of time. Much important planning data was missing, while included data proved to be misleading in some aspects. It must be borne in mind that data obtained in any one year, or even during four consecutive years, might not be applicable in the following years.

Data recorded during Deep Freeze I was gathered as a result of fundamental observations made to assist construction and air operations. Detailed weather records and analyses are contained in the CTF 43 Deep Freeze I report.

The data presented in this report is general in nature, depicting extreme and average conditions encountered at specific locations. Some observations were for very short periods, such as the 45 days during the establishment of the Pole Station. All records of weather observations are available at the National Weather Records Center (Navy Unit), Arcade Building, Asheville, North Carolina.

Little America

Aerological personnel were not provided for Deep Freeze II; however, with the onset of summer flight operations, TF-43 aerological personnel were provided. Material for this report was obtained from IGY aerological logs maintained in weather central at Little America.

Byrd

No Navy aerologists were assigned to Byrd Station. The weather program was the responsibility of IGY personnel.

Weather reports to Little America included one every three hours, two upper air reports every 24 hours, and a weather briefing to pilots returning to Little America. Two 12-hour forecasts were sent each day during periods of frequent flights from Little America and air drops. Storm warnings were sent whenever the wind went above 40 mph.

South Pole

The aerological program at South Pole during Deep Freeze II was carried out entirely by IGY personnel, with support in materials, maintenance, and manpower being provided by Naval personnel as required.

Hallett

The aerological office at Hallett was manned by three Navy aerographers mates and one U.S. IGY meteorologist. The aerological program began in early 1957, but the entire program was not in operation until March 1957 when equipment installation was completed. During the wintering-over period, approximately 3000 surface weather and 622 upper air (rawinsonde) observations were taken.

Ellsworth

The warm moist air of the south Pacific combines with the dense cold katabatic flow off the antarctic polar plateau in the region of Cape Dart at the western limits of the Bellinghausen Sea. This forms weather similar to the Polar front that occurs in the northern hemisphere. The low-pressure areas or waves formed on the antarctic polar front in the region of Cape Dart move eastward across the Bellinghausen Sea until they are deflected northeasterly along the west coast of the Palmer Peninsula. Upon reaching the northern tip of the peninsula in the region of the Drake passage, the low centers mix with air from the south Atlantic. This new source of energy pushes the low-pressure centers farther east causing turbulence both at the surface and aloft in the latitudes of 50 and 60 south. As the low-pressure centers move eastward along the 60-degree south latitude, a flow of cold, dense and heavy antarctic polar air feeds in behind the low centers. By zero-degree longitude, the heavy polar air underruns the relative warm moist air over the water, and deflects the warm air upwards, turning it south, back onto the antarctic continent. Veering to the southwest even further, the troughs, which have attained a height of 5000 to 10,000 feet,

settle into the pocket formed by the Weddell Sea. No classical fronts as we know them in the northern hemisphere were experienced at Ellsworth Station. However, the elevated troughs cause meteorological phenomena that can be explained. The type of precipitation, in the form of snow grains, ice needles, snow pellets, is indicative of turbulence aloft. The falling or rising of the barometer without the accompanying wind shift indicates the passage of elevated troughs. These observations will become confirmed as the analysis of the upper air soundings become extant.

DAYLIGHT

Continuous daylight exists at McMurdo from late October to late February. During this time, faborable weather and ground conditions permit around-the-clock operations. From late February to late April, the transition from continuous daylight to continuous winter nights occurs. Thereafter, and until late August, the darkness is broken only by short periods of civil and astronomical twilight. Then, the periods of daylight became progressively longer until, in late October continuous daylight returns. The table below elaborates on periods of daylight.

January 1 to February 20	Continuous daylight
February 20 to March 10	Alternate day and night, light night resulting from civil twilight
March 10 to April 1	Alternate day and night, light night resulting from astronomical twilight
April 1 to April 20	Normal alternating day and night; days progressively shorter
April 20 to May 15	Dark night with civil twilight at mid-day
May 15 to July 15	Dark night with astronomical twilight at mid-day
July 15 to August 20	Dark night with civil twilight at mid-day
August 20 to September 10	Alternate day and night; days progressively longer
September 10 to October 5	Light night resulting from astronomical twilight; alternate day and night

October 5 to October 20	Light night resulting from civil twilight; alternate day and night
October 20 to January 1	Continuous daylight

Due to topography of the area, the effects of twilight are not too significant at McMurdo, especially in the camp area at Hut Point with its surrounding hills. The ice area, which is more exposed, receives light earlier than does the camp area. Completely exposed locations, such as Little America, Byrd Station and the Pole Station, benefit greatly from the twilight periods.

WINDS

McMurdo

At McMurdo, prevailing winds are easterly, with storm winds predominantly southerly though occasional easterly storm winds are experienced. Local topography, such as Ross Island, has a distinct effect on winds, causing great variations of velocity and direction at the NAF McMurdo. Winds of over 90 mph have been recorded in the Hut Point camp area. On the ice, where winds are not disturbed, velocities nearing 115 mph have been experienced. September, 1956, was a month of high winds, while during November and December winds were nearly absent.

Little America

Refer to Table I

Beardmore

"Beardmore was usually very windy, as it was located near the confluence of at least five major glaciers. This invariably resulted in heavy blowing snow with attendant reduction in surface visibility."[1]

Byrd

Winds at the Byrd Station during January and February 1957 were predominantly from the north and never less than 5 mph. The maximum record in February was 52 mph.

"During trail party operations from Little America to Byrd Station, generally moderate winds were experienced. In November and early December, winds were predominantly southerly, but changed to northerly late in December. The average surface wind velocity was 2 to 3 mph, with a maximum of about 35 mph on 16 December."[2]

TABLE I. WIND IN MILES PER HOUR FOR 1957

Month	Little America		Byrd	South Pole	Hallett	Ellsworth
January						
Mean	10.3		11.5	10.4	10.5	-
Dir.	SE		NNE	-	SW	-
Pk.	-		40.6	-	61.0	-
February						
Mean	9.3		13.8	11.5	9.3	-
Dir.	SE		NNE	-	SW	-
Pk.	NNE 40.3		51.8	23	54.1	-
March						
Mean	13.5		-	12.7	11.0	-
Dir.	SE		-	-	SW	S
Pk.	40.3		-	32.2	69.1	-
April						
Mean	11.7		-	17.3	6.8	-
Dir.	S		-	-	SSW	S
Pk.	48.4		-	39.2	54.1	-
May						
Mean	15.9		18.9	17.3	8.4	-
Dir.	SE		NNE	-	SSW	NE
Pk.	NE 70.2		39.2	54.1	77.2	-
June						
Mean	17.3		17.8	19.6	19.1	-
Dir.	SE		NNE	-	SSW	S
Pk.	NE 62.2		54.1	38.0	92.1	-
July						
Mean	15.0		21.9	17.3	11.1	-
Dir.	SE		NNE	-	SW	S
Pk.	44.9		51.8	42.6	92.1	-
August						
Mean	16.1		27.1	18.4	7.7	-
Dir.	SE		NE	-	SW	S
Pk.	86.4		82.9	38.0	87.5	-
September						
Mean	11.5	(12.7)*	25.3	15.0	4.0	-
Dir.	SE-S		NE	-	SW	S
Pk.	NE 28.8	(61.0)	53.0	41.5	63.3	-
October						
Mean	17.8	(9.2)	17.3	16.1	13.5	-
Dir.	SE		NE	-	SW	S
Pk.	59.9	(44.9)	55.3	39.2	114.0	-
November						
Mean	11.1	(6.9)	-	-	7.7	-
Dir.	SE		-	-	SW	NE
Pk.	44.9	(32.2)	-	-	58.7	-
December						
Mean	-	(6.9)	-	-	8.3	-
Dir.	-		-	-	SSW	S
Pk.	-	(42.6)	-	-	59.9	-

* 1956 observations in parentheses

South Pole

During the short construction period at the South Pole, winds were very mild, especially in comparison to those experienced at McMurdo. The maximum on 35 of the 45-day period did not exceed 10 mph, and greatly facilitated operations during that period. Throughout the winter night, however, winds were unexpectedly persistent, averaging about 16 mph (though the peak gust was only 54 mph). Of over 4400 hourly observations between sunset and sunrise, only 25 recorded calm conditions. The prevailing wind direction was from the grid northeast.

Hallett

Surface winds during all storms were recorded in excess of 46 mph and the most severe of these occurred on the 22nd and 23rd of October when winds of 114 mph were recorded, with an average hourly wind for this period of 64 mph. All strong winds recorded at the station were from the southerly quadrant which coincides with the prevailing wind for the station.

TEMPERATURES (See Table II)

McMurdo

The minimum temperature experienced at McMurdo during Deep Freeze I was a -76 F. The maximum temperatures were in the low plus 40 F. There was a great difference (10 to 20 F) between temperatures recorded on the sea ice and in camp. On 6 August 1956, the temperature at the runway was -63 F while -40 F was recorded in camp. When winds were southerly, the temperatures tended to equalize. During most of December 1956, temperatures were over +32 F. The snow and ice melted rapidy. The development of dangerous potholes on the runway caused it to be closed to all wheeled aircraft from mid-December to early February. The warm weather also hampered unloading ships as cracks and weak spots in the shelf ice frequently halted tractor trains. In camp, accelerated melting brought forth gushing streams, undermining buildings and severely damaging the inadequately designed electrical distribution system.

Little America

The temperature at Little America varied from day to day as much as 50 F in 24 hours. A low temperature of -56 F was recorded in September 1956 with a high of +39 F in December.

Beardmore

Temperatures were about the same as McMurdo.

TABLE II. ANTARCTIC TEMPERATURES (F) FOR 1957

Month	Little America		Byrd	South Pole	Hallett	Ellsworth
January						
Max.	+40	(+40)*	+25	+5.5	+39	-
Min.	-2	(-2)	-17	-30	+20	-
Aver.	+20	(+21)	+10	-18	+31	-
February						
Max.	+30	(+26)	+21	-18	+34	-
Min.	-17	(-21)	-20	-69	+16	-
Aver.	+10	(+11)	+3	-37	+24	-
March						
Max.	+25		-	-35	+25	+25
Min.	-49		-	-83	-6	-38
Aver.	-15		-	-65	+12	-4
April						
Max.	+10		-	-26	+17	+25
Min.	-55		-	-89	-24	-35
Aver.	-27		-	-70	-3	-9
May						
Max.	+30		+20	-30	+11	+17
Min.	-63		-66	-100	-27	-61
Aver.	-23		-32	-68	-9	-13
June						
Max.	+25		+4	-42	+20	+8
Min.	-61		-70	-97	-36	-51
Aver.	-11		-28	-70	-5	-27
July						
Max.	+6		-4	-41	+7	+10
Min.	-61		-70	-99	-34	-60
Aver.	-32		-41	-78	-15	-27
August						
Max.	0		+8	-45	+19	+5
Min.	-56		-51	-100	-44	-58
Aver.	-30		-20	-73	-17	-33
September						
Max.	-3	(+21)	+1	-58	+15	+20
Min.	-51	(-56)	-61	-102	-34	-55
Aver.	-29	(-22)	-23	-80	-10	-17
October						
Max.	+29	(+7)	+12	-45	+28	+13
Min.	-43	(-46)	-55	-86	-21	-32
Aver.	-3	(-20)	-15	-63	+1	-13
November						
Max.	+30	(+30)	-	-	+36	+31
Min.	-16	(-29)	-	-	-5	-31
Aver.	+9	(+2)	-	-	+19	+9
December						
Max.	-	(+39)	-	-	+40	+32
Min.	-	(+6)	-	-	+19	+9
Aver.	-	(+23)	-	-	+30	+21

* 1956 observations in parentheses

South Pole

Temperatures were mild compared to the anticipated temperatures of -35 F used as a planning figure. During the 45-day construction period, -35 F was the minimum, with the average temperature being more nearly -5 F.

The maximum temperature recorded to date at the South Pole is +5.5 F; the minimum a world record -102.1 F. Summer temperatures are warm enough to permit relatively easy accomplishment of outside work, particularly as winds are light. The winter night period (22 March to 23 September) averaged about -73 F, with temperatures below -58 F for 90 percent of the time, and below -90 F about 12 percent of the time. Average daily temperatures ranged as low as -96 F.

Byrd

Observations were limited to January and February 1957. The minimum temperature of -20 F was recorded in February. The maximum of +25 F was recorded in January. During both mcnths the average temperature was above zero.

"Temperature observations during trail operations spanned the period of 5 November 1956 to 6 January 1957. On the Ross Shelf at elevations of less than 200 feet the minumum temperature was -22 F on 11 and 12 November. The maximum of +28 F was observed on 28 December. At Mile 183.5 on Army-Navy Drive, where the plain of the Ross Shelf joins the Rockefeller Plateau, the temperature recordings ranged from -16 to +30 F."[2]

Wilkes

The climate is very mild for the Antarctic, low -27 F, high +48 F. The low monthly average was just above 0 F, the high monthly average just above 32 F. This is due partly to the relatively low latitude (this bulge of eastern Antarctica is the only section except the Palmer Peninsula which extends north of the Antarctic Circle) but to an even greater extent it is due to local factors. Winds pouring down off the ice cap warm the area (by air friction) and, more important, they prevent extensive accumulation of ice in the island group. The presence of nearby open water at a constant 28 F to 29 F temperature results in a stable, relatively high temperature, really milder than that often encountered in the northern United States.

PRECIPITATION AND FOG

McMurdo

The hills and dark volcanic earth of Ross Island cause a great deal of melting during the summer (as do the dark moraine fields out in the Sound) as they absorb a great deal of heat. The melt water runs off onto the sea ice and causes extensive stratification. Large fields of blue ice, which look like solid fresh water ice, were found by corings to be highly stratified with snow. These blue ice fields exist adjacent to Arrival Heights on Cape Armitage and about 10 miles from camp adjacent to the moraine field which flows from Black Island. In general the snow thickness covering the old sea ice within a 4-or 5-mile radius of camp runs from 30 to 40 inches. In Winters Quarters Bay where drifting is caused by the neighboring hills, snow depths exceed six feet in places. Beyond a 5-mile radius, the snow tends to decrease in thickness to about 12 inches.

The snow is composed of very fine granules less than 2mm in diameter. The granules are extremely dry. The average density of the snow is greater than 0.4 gm/cc. Hardness varies from very soft strata to strata with 10,000 gm/cm^2 hardness gauge readings. The constant winds pack the snow, and warm temperatures during the summer help to increase its density. The snow on the new ice to the north beyond the Deep Freeze I offloading site was only 4 to 6 inches in depth with the same general characteristics as the snow on the old ice, except stratification had not developed.

On the sixth of May a marked inversion, commencing at approximately 500 feet altitude appeared over McMurdo, which created an appearance of fog for several hours as the smoke from the building's smoke stacks leveled off at the inversion's base and reduced visibility considerably.

Little America

Fog

Fog and white-out conditions were prevalent during the winter and summer months and presented the greatest hazards to air operations.

Snow Accumulation

Approximately 170 inches of snow accumulated around the Little America site between February and November 1956. There was very little snow accumulation on the roofs of the buildings. This was evidently due to the flat surface the roof presented. It was noticed that objects which presented a flat surface on the top had very little snow accumulation, as the wind would keep the top clear of snow. Digging was required for replacing the fuel drums for the space heaters. A freezing drizzle was recorded on 22 November 1956 with a surface temperature of +5 F. Average relative humidity was estimated at about 5 percent.

South Pole

Ice fog appeared quite often at the Pole. Sun spots(parhelion) and other refractory phenomena were often observed.

Cloud cover is extremely variable, and can change with great rapidity. Sun dogs and halos are common. Near-blizzard conditions occurred infrequently during the winter, but were not experienced during the summer. Whiteout conditions, ranging from partial to almost complete, were fairly common. Annual precipitation is slight, probably not exceeding 6 inches of snow accumulation yearly.

True white-out was rare at the South Pole. Only one day occurred during which the conditions could be called true white-out. On this particular day the snow surface lost all shadow, objects seemed to float in space, and one had a tendency to stumble over the sastrugi. Fortunately the station is the highest object as far as the eye can see, so there is always a landmark, and white-out condition is of less practical importance than at coastal stations.

In looking for a reason for the lessened incidence of white-out, one is again confronted with one of the primary differences between the weather here and at the coast. Whereas, the latter has frequent low cloud formations, the South Pole by virtue of its altitude of 9200 feet seldom has heavy banks of low clouds. The high cirrus cloud found over the Pole is apparently not as good a reflecting surface as the low clouds. It should also be noted that the sun's elevation here is seldom (or not for long) high enough to give the multiple reflections required to produce white-out.

An interesting but unsubstantiated observation was that one may on rare occasions after sundown have what might be called a "grey-out" during which time, although there may be light enough to see, all shadows merge, and the Plateau, which is usually well broken by sastrugi, appears to be perfectly flat and of uniform shade.

Hallett

The Cape Hallett area was considered to have had a not too severe winter in 1957, as the station had only one extended blizzard and averaged only 2 severe storms per month during the period.

DRIFTING SNOW

At Little America, drifting snow settled against the side walls of the building extending to the roofs and against the sides of the tunnels and covered storage areas. This presented no problem rather, the insulting effect was helpful in maintaining warmth in the buildings and blocking

winds in the tunnels and storage area. No measures were taken to prevent drifting. Drifting will occur around any obstacle. During the summer and and winter precipitation appears to be very slight. During the spring and fall precipitation and drifting is heavier. Windrows of snow, depressions, equipment, building, etc., cause large accumulations of snow. A smooth area, such as a new ice field or as unobstructed roof tops, will gather little snow. When clearing or leveling an area, all equipment must be kept off of the area when not working, as a storm will undo weeks of work by drifting around the equipment. Winds and drifting snow must be taken into account in the design and location of any buildings and structures. September, a month of high winds and heavy precipitation, was a severe month during 1956. Perhaps it, of all months, bears careful watching.

By September the drifts at Kiel Field were up to the tops of the buildings and 3 feet over the buildings in one place.

ICE FORMATION

Incident to the selection of a site for the runway at McMurdo, the sea ice was observed throughout the winter months. Numerous holes were bored with hand coring augers and a hydraulic auger attached to a D2 tractor. The ice was more than a year old and had not gone to sea during the summer of 1955-56. The thickness of the old sea ice was found to vary considerably. Presumably, currents are the primary erosive agent. In Winter Quarters Bay, the ice exceeded sixteen feet in depth. In some places it was fused to the bottom. The progressively farther west and south, varied from eleven feet to approximately fifteen feet at a 2-mile radius. Beyond this radius the thickness was judged from the level of the water in tidal cracks. It is estimated that at four miles radius the ice was 25 to 30 feet thick.

In general the ice at McMurdo Sound, once it grows to a point where it is relatively stable, grows at a rate of from 3 to 5 inches a week until it reaches a thickness of 78 to 80 inches. At this thickness the ice appears to insulate itself reducing the rate of growth. As the water temperature remains cold, the ice will continue to grow, even though the air temperatures are relatively warm. The measurements taken by Deep Freeze I personnel differ slightly from those of Scott's, as recorded during his first journey to Hut Point in 1903-04. The plot of data (Figure 2) obtained by Deep Freeze I, and that of Scott, compared with average air temperatures recorded for 4 years (Simpson, G. K. "Meteorology") shows the time lag of the ice formation behind the air temperatures. It is believed that Scott's test hole, which was off Hut Point, might have been influenced by currents. However, both Scott's and Deep Freeze I plots indicate a growth of ice up to approximately 100 inches and a sharp fall in thickness about the second week in December and early January.

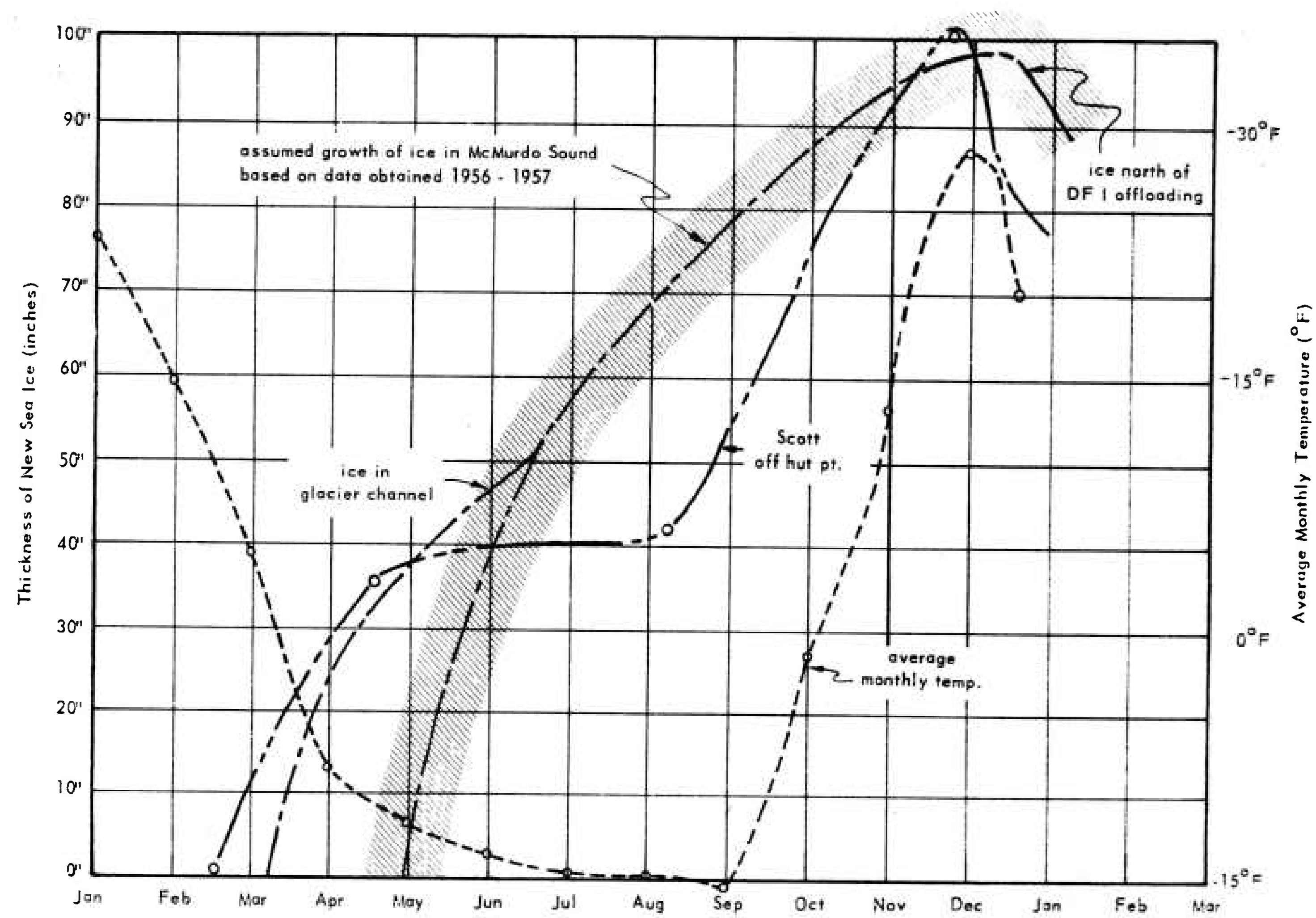

Figure 2. Ice growth versus temperature, McMurdo Sound, Antarctica.

The ice to the north of the off-loading site grew at a higher rate and eventually reached the same thickness as the ice that started to freeze earlier in the season. The reason for the northern ice starting to form later is that it is more exposed to the elements and is blown to sea more readily.

The ice is thinner along the shore where the water is shallower and currents are faster. This was clearly indicated during the summer when the shoal areas off of Observation Hill and Hut Point became progressively dangerous. Ice surrounding these areas remained solid while the ice immediately above the shoals eroded from beneath. The Hut Point shoal was the scene of a death in early 1957 when a weasel broke through the ice, drowning one occupant.

Salinity tests taken in April 1956 showed a very low salt content in the old ice. The ice had an average water content of 88 percent. The uniformity of the ice varies not only horizontally but also vertically. This is apparent from the resistance of the ice to drilling.

Vertical Ice Movement

A tide gage, furnished by the Navy Hydrographic office and modified prior to installation, obtained limited data. The ice cover precluded the float from resting on the water surface so the level of the top of the ice was measured with respect to the bottom. A hole was drilled in the ice, a pipe inserted and frozen into the ice. The recording mechanism was mounted on the top of the pipe. A weight, substituted for the float, rested on the bottom. As the ice rose and fell with the tide, the mechanism rose and fell relative to the bottom. The gage or recording mechanism was delubricated and relubricated, using low temperature oils developed for cameras. The problem that could not be solved, and which prevented the accumulation of useful data, was the freezing of the wire in the pipe. All sorts of POL were tried but with no success. Rough measurements with a transit indicated a tide range of 3-1/2 to 4 feet. Extreme vertical tidal movement was evident at certain phases of the moon, when large tidal cracks opened and closed along the shores.

Horizontal Movement

The bay ice is continually being pushed seaward. The winds and currents constantly tend to push the ice around, especially when it has cracked free of the parent ice. The pressure from the great ice barrier causes plastic flow. This is clearly demonstrated by the huge pressure ridges behind Cape Armitage in the vicinity of Pram Point, as well as by precise measurements taken during August 1956. At that time, measurements with a theodolite, using a range pole located 6850 feet at 210° True from McMurdo Aerology Benchmark (South II) indicated that the ice

at the range pole moved an average of eight to nine inches every 24 hours toward the northwest (300° True). The period of observation was four days. It is believed that the ice flows much faster during the warm summer months as the pressure ridges are more active at that time.

Total ice movement is unpredictable. The ice is constantly being shoved around by currents, tides, winds, swells from the north, and pressure from the barrier. Wind alone would not normally cause ice break-up. Large cracks opened up from Glacier Channel toward Black Island in August and September 1956 for no apparent reason. During a sledding trip to Cape Royds in September the party awakened to find that all the ice north of the Cape, which had been solid the preceding night, had blown to sea, even though the preceding night was calm. The ice must be watched constantly.

"A southerly wind combined with wave action takes ice out to sea quickly."[3] "Ice formation begins early in March, but breaks up and blows out to sea north of off-loading site. Cracks continue to develop in the ice around the base, and tidal action is evident. Several large cracks were up to 3 feet, 6 inches wide. By early May a narrow section of several hundred yards about 33 inches thick has been able to remain in place during the recent high winds (with gusts up to 58 mph). During the week of 21 May 1956, all new ice north of the off-loading site, with the exception of a 1500-yard bend 30 inches thick, was carried out to sea."[6]

Description of Sea Ice

None can tell when the sea ice will break up and go to sea. Records of the past expeditions to McMurdo Sound indicate that the disruption may be abrupt (as was the case when Bowers, Cherry-Gerrard and Crean were caught in 1911) or gradual (as was the case during Deep Freeze I). Many square miles may go to sea during a calm night. Whether the ice will reform is questionable. Planning operations in an area such as McMurdo Sound, revolves about the ice. The ice is not predictable. Therefore, plans must account for any possibility. M-boats, pontoons and dinghys may be as important to off-loading as tractors and sleds. Bridging material is required. But above all, constant vigilance must be maintained.

THAW

November and December 1956 were months of almost uninterrupted sunshine at McMurdo and temperatures were over +32 F. Deterioration of the trail over the sea ice slowed the tractor trains and inflicted irreparable damage to the equipment. The ice weakened and it was necessary to constantly patrol the trail to assure the absence of wide cracks

and dangerously weak spots. Although the warm weather hampered ship off-loading, the most seriously affected were air operations. By the middle of December it was necessary to close the ice airstrip to all wheeled aircraft because of severe melting and development of dangerous potholes. At this stage, vital material and personnel still were required at Pole and Byrd Stations. Many hundreds of man-hours were expended in efforts to effect repairs, only to be frustrated by recurrence of warm weather and worse melting than before. Each of these efforts upset the camp organization and drained men from other needed work. In the camp itself, the warm weather caused melting and brought forth gushing streams. These flowed through the camp, undermining buildings and severely damaging the inadequately designed electrical distribution system. Much mud at the camp.

"At Little America high temperatures caused some buildings to be undermined from fast melting snow footings. Tunnel to the Geomagnetic Observatory most affected. Repacked with snow."[21]

"A definite drainage problem is foreseen at ATROPFAC. Hugh drifts and waste water pumped from the powerhouse is ponded by the powerhouse. Constant ditching will be necessary this spring."[6]

EARTH TREMORS

McMurdo

On the 29th of April 1956, earth tremors were felt and they were of such duration as to prevent the bubble in the theodolite from settling down over a ten minute period. As no heavy equipment was operating in or nearby the camp, Mount Erebus was given credit. On 6 May another marked earth tremor was felt in camp.

South Pole

On 21 November 1956, a very great tremor was felt rolling past the camp from grid northeast to southwest. The tremor was so great that all personnel sprang from their tents thinking that the C-124 had crash-landed adjacent to the camp.

AEROLOGICAL STAFFING AND EQUIPMENT

Personnel Requirements

Hallett

The aerological personnel at Hallett Station were required to work an average of 12 to 14 hours daily. This work period was often increased by camp duties. During the fly-in period, the work load was again increased.

It is recommended that through coordination between the Navy Weather Service and the USNC/IGY, the station allowance should be increased to five meteorological personnel. This would reduce the work to an acceptable daily load and provide sufficient manpower to allow a continuous meteorological program in the event of accident or sickness to personnel concerned.

Ellsworth

Aerological personnel were experienced enough to handle most aerological problems; technical difficulties with electrical equipment were adequately taken care of by the electronics technician.

Equipment

Rawin Set AN/GMD-1A

The automatic radiosonde tracking device was in its second year of use at McMurdo. No ascensions were missed due to equipment failure. The gear was located on the roof of the aerology building using the shelter (V16AN-S78U) designed for it. The shelter withstood winds up to 94 mph with no harmful effects. Ducts from the Jet heater located in the office were kept on the gear, but since this was insufficient heat, the gear was left in standby when not in use.

Occasionally the power supply source dropped below 95 volts resulting in overloads, but upon throwing the reset switch the gear returned to normal. After installing a booster cable from the communication building it was possible to keep a normal 115 volts.

At Ellsworth, during extremely low temperatures, and due to inadequate heating of the dome, over-loading occurred. The instrument functioned satisfactorily in temperatures ranging from -40 F to the highest temperature of +30 F. The instrument was kept constantly in a standby status to utilize the heat produced by the tubes. This instrument is used in conjunction with radiosonde receptor AN/FMQ-2A which records on a paper roll the elevation and horizontal angles observed by the instrument.

AN/GMB-1B Automatic Radiosonde Tracking Device

The performance of the AN/GMB-1B upper air sounding apparatus was considered very good at Wilkes. No upper air soundings were missed because of equipment failure and only one upper wind sounding was missed for this reason. This failure was in the time print unit of the control recorder. Use of a stop watch enabled completion of the upper air program. Considerable difficulty was experienced with the 3023 thyratron tubes early in the program. In November on the recommendation of the

ETC, the meter reading for sensitivity adjustment was reduced from .7 ma to .6 ma. Thereafter only one failure was experienced in January 1958.

The location of the AN/GMB-1B antenna could be considerably improved at Wilkes. After beginning the program, it was found that whenever nearby radio transmitters were operated the recorder trace would become very erratic and unusable. Radiomen were therefore instructed to refrain from using transmitters while soundings were in progress. This condition was later corrected by connecting the radio transmitters to a Vee antenna. The effect of the radio masts on the accuracy of the upper air soundings was checked by a USWB Meteorologist, using a theodolite and was not judged by him to be great enough to necessitate relocating the antenna. It is recommended, however, that future installations of the AN/GMB-1B antennas be as far from radio transmitting equipment as practicable.

Radiosonde AN/AMT-4

These instruments operated satisfactorily at Hallett. A few troubles of an insignificant nature were encountered with any other standard instrument furnished. Routine electronic maintenance kept the rawin set and its component part, AN/GMD-1A, operating satisfactorily. This tracking set was located on the roof of the mess hall. It was not necessary to build a tower.

Radiosonde AN/AMT-4A

The complete unit, consisting of the modulater, transmitter, temperature, and humidity elements, was installed at Ellsworth. Less than one percent of these instruments were rejected due to malfunctioning.

Radiosonde AN/AMT-4B

McMurdo rejected very few of these instruments. While first checks sometimes resulted in rejection, second checks were made showing the instrument to check out. The temperature support arms on this instrument proved much more reliable than the AN/AMT-4A as only two releases with no temperature signal could be traced to broken temperature elements. These occurred with winds at 40 to 58 mph.

The radiosondes supplied to Wilkes which were manufactured by Molded Insulation Company, Philadelphia, Pa., proved to be of very poor quality. During the period 14 March to 31 December 1957, 12 percent of all radiosondes tested were rejected because they did not baseline satisfactorily. During this same period 15 soundings were terminated because of flight equipment failure. In addition second releases were necessary on numerous occasions because of flight instrument failure at low altitudes. The construction of these instruments was such that it was quite difficult to make a second baseline check when necessary.

The commutator bar on most of the instruments was very uneven, and often three to five or more temperature contacts would be missing during a sounding. It is recommended, therefore, that equipment of another manufacturer be supplied if available. The baseline check set greatly interfered with nearby communication receivers. No satisfactory solution was ever found for this problem.

Radiosonde Recorder AN/TMQ-5A

During the winter months the temperatures aloft became so cold at McMurdo that the ordinate values on the recorder went below 5 on each ascension and occasionally to less than 3 ordinates. This resulted in a very shaky trace unless the sensitivity was reset. It was not possible to set the sensitivity so that it would operate from 95 ordinates down to less than 3.

Voltage requirements for the gear are from 105 to 125 volts, but the gear would operate satisfactorily down to about 95 volts. Several times during the early part of the year the voltage would drop below 95 volts and at this time the pen arm would fail to drop down onto the paper.

The TMQ recorder performed very well at Wilkes. The onl, fault to be found is the ballpoint pens. Three were used in 11 months of operation. A number of traces were very poor because of them.

At Ellsworth Station this instrument worked in conjunction with rawin set AN/GMD-1A and radiosonde receptor AN/FMQ-2A. Uninterrupted pressure, temperature and humidity data is recorded. The only difficulty at Ellsworth with this instrument occurred with a drop in power below 50 cycles at which time the pen arm would not reach the right hand high and low reference marks on the paper roll. One or two soundings were incomplete because the rolls did not have the stated number of 120 feet. This resulted in the loss of valuable information.

Wind Measuring Set AN/PMQ-3A

This was occasionally used at McMurdo and was the standard wind measuring set at Liv camp. No maintenance problems occurred. Ellsworth Station used this hand-type instrument extensively during the construction period. A visual reading of wind direction and force, pressure, temperature and humidity can be obtained. The traverse party was supplied with an instrument and field readings were obtained. No maintenance problems were encountered.

Wind Measuring Set AN/UMQ-5

Although this is a field unit, it was used as a permanent installation at Ellsworth. Once orientated and put into operation it presented no difficulty. An auxiliary unit for making a permanent record on a paper role was cut into the circuit. Some turbulance caused by camp building was noted with winds under 17 mph. This situation gradually corrected itself as the snow drifted to the top of the buildings and eliminated the turbulence.

Wind Measuring Set AN/UMQ-5B

The transmitter at McMurdo was located alongside the thermoscreen and secured with guy wires which required occasional checking as they would come loose. No other maintenance problems were encountered here.

Recorder RD-108/UMQ-5

This wind direction and velocity recorder had an outage of one day at McMurdo, due to equipment failure. The failure was due to a power surge which burned out the synchro.

Balloons

McMurdo. A large number of Marshall Rubber Company 500-gram balloons were available at McMurdo but only a few of these were used, and only during periods of calm or light winds due to the weak necks.

Day and night sounding balloons manufactured by the Molded Latex Company, were used from January to November 1957. From January through February, day sounding balloons were used with average (ascent) heights of between sixty to sixty-five thousand. These were hung up in the office near the heater for 24 hours before inflation. Previous to this they were stored inside for a few days. In March 1957 all balloons on hand were stored on shelves built a foot below the overhead to keep the balloons at a temperature between 65 and 75 degrees. But the humidity was between 15 and 20 percent which resulted in the balloons drying out. During March, with the winter night setting in, night sounding balloons were put into use with heights remaining the same for a couple of weeks. From March on, day sounding balloons were used only during periods of high winds when it was impossible to release the larger night sounding balloon. It was almost impossible to get above 50,000 feet with the day sounding balloon and frequent bursts occurred around 30,000 feet. Heights began to drop again by the middle of March, so the five minute hot water treatment replaced the dry heat method; but results remained the same. Alcohol and gasoline were used next. The balloon was soaked in either alcohol or gasoline for one minute before inflation. The liquid was not heated, but used as it was when brought in from outdoors. Heights

remained above 60,000 feet until April, then began to fall off again. At this time diesel fuel was tried and results were so good that it was used until November. The balloon was soaked in warm diesel for five minutes just before inflation. About a quart of diesel fuel was inserted inside the balloon and using neoprene gloves, it was carefully shaken until the inside and the outside of the balloon was entirely soaked. It is very important not to lift the balloon from the liquid while there is liquid inside the balloon as this weakens the balloon. In April the diesel was heated to around 75 degrees, but as temperatures aloft became colder the temperature of the diesel had to be increased to obtain the same results. By late July the diesel temperatures were between 140 and 160 degrees. In August, heights began to drop off again, so the temperature of the diesel was slowly decreased and was down to 70 degrees by early September. In November it was necessary to switch back to alcohol to maintain heights above 60,000 feet. The alcohol was used at 65 to 75 degrees.

Reels were used with every release at McMurdo as all releases were made by one man. When it was possible to observe the balloon for a length of time it was frequently noted that the reel failed to unwind after the release.

The shroud was used at McMurdo only when the wind was blowing into the doorway. But when it was used it was always too small even for the day sounding balloon. This was due to the method used to condition balloons which resulted in larger balloons than normal. For this type of conditioning a shroud at least 25 percent larger should be made available.

Hallett. Two types of 500-gram radiosonde balloons manufactured by Molded Latex Company and Dewey Almy Company, were furnished Hallett. The Dewey Almy balloons were not used until early spring, but with their usage the average height reached on ascent increased approximately 7000 feet over ascents made with Molded Latex balloons. This difference in height is not attributed directly to the quality of the product, as warmer temperatures aloft and other factors must be considered. But it was believed worthy of mention. All balloons were conditioned by a method developed in Antarctica, which was to soak balloons in warm diesel oil, gasoline or alcohol prior to inflation. This method proved very satisfactory in improving heights over the standard methods recommended in the Manual for Rawinsonde Observations.

Wilkes. Considerable controversy arose during the year among the antarctic bases concerning various methods of balloon conditioning. Wilkes tried hot air, hot diesel oil, warm gasoline and hot water. The diesel oil conditioning process was used during August and the first half of September, but nothing was apparently gained from this process and it was considered a fire hazard. Tests were conducted in mid-September

using the hot diesel oil method and the hot water method, and the hot water method was used exclusively thereafter. The results of the test period showed a net average of 2000 feet higher with the hot water method. Continued use of the hot water method resulted in Wilkes assuming the lead in average altitudes of the U. S. bases in October and maintaining that lead for the remainder of the year. In December an average altitude of 88,557 feet was obtained, an extremely high average under any conditions. It is recommended, therefore, that all soundings released during daylight hours be conditioned using the hot water method. Further research should be conducted to determine the correct method for winter darkness.

Ellsworth. Molded latex balloons were used exclusively at Ellsworth. These were conditioned in a tinfoil-lined hotbox using a 100-watt bulb. During the winter night the balloons were dipped in hot diesel fuel. The dipping process was terminated upon reappearance of the sun. Shrouds were used at Ellsworth to facilitate, release and protect balloons in high winds. The shrouds issued were too small, especially during the period when the balloons were soaked in diesel oil and expanded a third again their normal primary inflation size. An adequate supply of helium was furnished at Ellsworth and was used exclusively until the hydrogen generator was assembled. The only difficulty with the use of helium was the type of hose furnished. The hose was pure rubber and became brittle in the extremely low temperatures. Recommend the type used with acetylene equipment. This type retains its elasticity in the lowest of temperatures.

No difficulties were encountered with the Gill hydrogen generator at Ellsworth, but there was trouble with moisture getting into the balloon until the following method of draining was discovered. As the balloon lift equals the weight of the attached weights, let the balloon receive a little more gas. Leaving the outlet valve open, throw the drain and flushing lever as rapidly as possible. The resulting flushing action pulls gas and water from the balloon back into the filling hose and machine. The outlet valve is closed and the water is no longer in the balloon. This reverse action takes only a few seconds and only the excess gas and water is pulled from the balloon.

Hydrogen Generator RS52A

McMurdo. At McMurdo, the generator is located in the rear of the inflation shelter. The heat source to keep the generator warm was kept in another building with the heat fed into the inflation shelter through ducts. Without heat it was possible to generate gas when the surrounding temperature was as low as 20 F, but below this it was not possible to turn the controls. When there was a failure of the heat source, bottled helium was used instead of forcing the controls on the generator. Another hazard encountered when attempting to generate gas with temperatures below

20 F was ice forming inside the generator. When generation caused temperatures inside the generator to rise enough to melt the ice, there was a rapid increase in pressure which ruptured the safety diaphram or blew off the radiator cap.

It was possible to make two charges in succession with no large increase in temperature, but if a third charge was made the temperature would increase to 150 F and the heat would cause the rubber in either the balloon or the rubber neck used in the inflation kit to melt. If the heat was turned off, and the generator allowed to cool for about half an hour after the second charge, it was then possible to make a third charge. Usually this was not practical because of weather conditions or time limitations.

Frequently there was a large amount of water in the balloon that had condensed from the steam that was mixed with the gas. A tractor filter was obtained from the garage and attached to the cold outlet. This allowed the gas and steam mixture to enter the filter at the top where practically all the steam condensed and settled at the bottom, allowing the gas to escape through another opening at the top. After the charge was completed, a cap at the bottom of the filter was removed allowing the water to drain out.

Hallett. This generator operated very satisfactorily at Hallett. The only recommendation is for an increase in the allowance of the polyethylene inflation hose furnished. In most cases a longer section of this hose would be suitable.

Aluminum Chips and Caustic Soda

McMurdo. Many of the cans of aluminum chips were damaged in shipment resulting in snow seeping into the cans. Each can was checked when it was brought inside, and if snow was found in the can it would be necessary to remove it. Otherwise the snow would melt, resulting in premature generation during the mixing of the chemicals. This was not possible when the heat was left off between charges, but with the heat left on it is possible.

All of the caustic soda shipped for Deep Freeze I was usable, while only sixty to seventy percent of the Deep Freeze II shipment was usable. Moisture in the containers resulted in solidification of the caustic soda. Most of this was so hard that it was impossible to break it up.

Wilkes. The aluminum chips were received at Davisville, Rhode Island, in cans of different sizes. This made it extremely difficult to palletize them for shipment. Several of the pallets were broken and a large quantity of the aluminum chips was lost by the time they arrived at Wilkes. Fortunately sufficient aluminum remained to complete the program.

Hygrothermograph

McMurdo. The temperature portion of this instrument proved to be reliable to within three or four degrees at all ranges of temperatures encountered (-40 F to +40 F). The humidity trace was reliable at temperatures above 15 F, unreliable between 0 F and 15 F, and at temperatures below 0 F the humidity element failed to work entirely.

When first put into operation new clocks would freeze within a few minutes. In order to overcome this, new clocks were taken apart and soaked in alcohol for a few hours and then thoroughly dried. After this process, no trouble was encountered and the clocks kept good time through all ranges of temperatures encountered.

It was very difficult to obtain a continuous trace due to blowing snow. From April until November almost every trace had some missing data due to snow getting inside the instrument. The snow would make the ink run, resulting in a very wide trace, and during high winds the inside of the instrument would be entirely filled with snow, at which time the instrument would be brought inside to be cleaned. This resulted in loss of trace for a few hours as the instrument would have to be thoroughly dried out before putting it back in the instrument shelter. Purple ink was used during the entire period and this proved very satisfactory.

In order to keep snow out of the instrument and obtain a continuous trace, it is recommended that a cover, possibly of nylon or other such material, be used to cover the instrument during periods of blowing snow. This will probably result in a temperature lag, but this would be better than no trace at all.

Hallett. The hygrothermograph did not operate in cold temperatures at Hallett due to the use of heavy clock oil which caused the clock to stop. This condition was eliminated by washing the clock in 95 percent grain alcohol. The humidity element of this instrument is not considered the best for the low temperatures of the antarctic. The element was considered reliable only at temperatures above 20 F. During periods of high winds and blowing snow, it was necessary to remove the hygrothermograph from the thermoscreen as snow would get inside the instrument, and this caused the entire temperature humidity trace to be rendered useless.

Ellsworth. Outside exposure proved unsuccessful at Ellsworth. The range of the chart was from 10 F to 110 F, and the humidity measured 0 to 100 percent. Weddell Sea temperatures ranged from 30 F to -64 F. Consistent high winds and blowing snow fouled the pen arm, hair element and clock works. Psychrometric readings were relied on for humidity information.

Thermograph

The thermograph located at McMurdo was usually accurate to within two degrees and would continue to record for hours after the hygrothermograph failed due to blowing snow. However, during periods of very heavy blowing snow this instrument would also fail to record. The clock was treated in the same manner as the hygrothermograph clock with the same results.

Theodolite

Used at Beardmore in temperatures down to -30 F with no maintenance problems.

Theodolite - Shore Type

The dome in Aurora tower at Ellsworth was utilized and a permanent stand was constructed. Conditions were such, however, that if a Rasonde flight was rendered impossible, the ceiling and visibility rendered the theodolite useless.

Microbarograph

Used at McMurdo and Beardmore with no maintenance problems.

Mercurial Barometer

Two of these were set up in the aerology building at McMurdo. No maintenance problems.

Aneroid Barometer

Used at Beardmore. No maintenance problems.

Thermometers

An ample supply of Navy issue thermometers were available at McMurdo but their low range was too high to be useful during the winter months. Standard, maximum and minimum thermometers were available with the temperature range desired but no corrections were furnished with these and some were found to be in error up to five degrees. By making numerous comparisons it was possible to obtain corrections. It was very important to get these corrections as accurate as possible because the slightest error at very cold temperatures results in a very large difference between the indicated and the true humidity and dew point.

The wick of the wet bulb thermometer was kept coated with a thin coating of ice and by using care in reading the thermometers, fairly

consistent dew points and humidities were obtained. The temperature would fluctuate as much as twenty degrees in a few minutes. Occasionally the wet bulb reading would be higher than the dry bulb. This occurred when the temperature was decreasing rapidly and the wet bulb was lagging behind the dry bulb temperature. During these periods a second reading was made after the temperature became steady.

The standard Navy aerological thermometers were sufficient at Hallett and operated well within their range. Most of the special low-range thermometers furnished were shipped as standard cargo, consequently they were subjected to temperatures well above their range, which is believed to have caused some error.

Adequate for middle ranges of temperature -30 F to 30 F at Ellsworth. Extreme temperatures were obtained by using alcohol filled minimum thermometers. Humidity evaluations were dispensed with below -40 F.

Check Set

At McMurdo the location of the salt tray resulted in spilling, which cut down the life of the relays directly under the salt tray. Placing the salt tray on the floor eliminates this, but instruments required slightly longer exposure before baseline checks due to humidity inside the buildings averaging 15 to 20 percent.

Thermoscreen

Not constructed at McMurdo because the louvered sides permitted blowing snow to enter the shelter, necessitating a thorough brushing out after every storm.

Battery

McMurdo. Terminations due to fading signals were held to the minimum and these were due to distance as one instrument was tracked to a slant range of 365 miles, and another was tracked for more than four hours. The battery was filled with water and allowed to set for one minute and then emptied and shaken. After setting for ten minutes it was again shaken. The method that proved to be the best for removal of all water from the battery was to squeeze it after shaking it. While the battery did not look usable after squeezing, it resulted in long hours of service.

Ellsworth. These were well protected in metal containers and failures occurred in less than one percent. In some cases rough handling in shipment caused the stiff internal dividers to pierce the waterproof outer casing. This damage was remedied with the use of masking tape.

Section III

COMMUNICATIONS

RADIO

General Conditions

Communications for the seven U. S. antarctic stations were handled by two separate major networks. The first network was the U. S. Naval Communications System which connected the six U. S. Naval IGY Stations with McMurdo. McMurdo is connected in turn with the Naval Communications Station at Balboa, Canal Zone, for introduction of traffic into the normal navy channels. The second network, called the Mother-Daughter Network, was international in scope and provided the weather communications channels from all U. S. and foreign antarctic stations to the IGY Weather Central at Little America.

Communications Central for the U. S. Naval Support Units in the antarctic was located at McMurdo. All weather data from the over forty U. S. and foreign antarctic IGY stations passed through McMurdo in the Mother-Daughter Network. All traffic between Antarctica and New Zealand or the United States passed through McMurdo. The majority of all messages between the U. S. antarctic bases, including ComNavUnits Antarctica traffic, passed through McMurdo.

However, the Command Headquarters of ComNavUnits Antarctica (now ComAntarctic Supp Act), the scientific headquarters of the Deputy Chief Scientist and the Antarctic IGY Weather Central were all located at Little America. The result was that all traffic entering or leaving the antarctic continent and the majority of traffic among U. S. bases on the continent was required to pass through Little America as well as McMurdo. There was a concomitant duplication of traffic handling.

During the antarctic summer, air operations control and Navy Weather Central were located at McMurdo. Associated traffic between ComNavUnits Antarctica and ComNavSupFor Antarctica was passed back and forth between Little America and McMurdo; there was also a great need for rapid handling of weather data and flight advice between both stations.

The first year's operations in the antarctic established McMurdo and Little America. Communications presented difficult problems due to types and quantity of equipment available and personnel backgrounds for technical planning and installation. Antarctic Communications Central was originally planned to be located at Little America, where command and IGY headquarters and the Antarctic IGY Weather Central were to be located. This logical location of "command and communications" together was changed early in 1956, and McMurdo was designated Communications Central. Although this change may have been justified for several reasons, it caused a considerable multiplication of the communications work load and increased the difficulties of coordinating Weather Central and navy communications efforts. Throughout the year 1957, Little America received inquiries from many of the foreign stations indicating confusion concerning the split of Communications and Weather Centrals and repeated requests from some stations to pass traffic directly to Little America.

In the antarctic summer 1956-1957, Pole, Byrd, Wilkes, Ellsworth and Hallett stations were added, and again communications effectiveness was influenced by the conditions under which technical and operational planning was carried out, by shortages of spare parts, types of equipment, and by short personnel allowances. In October of 1956 a communications expert from CNO reviewed the communications situation and recommended major equipment and personnel augmentations which were effected by December of the same year. The additional equipment and personnel greatly improved the communications capabilities.

The successful performance of the antarctic communications installations was made possible only by the tireless ingenuity of the wintering-over ET's and RM's who learned as they went. However, the efficiency of all the bases would have been considerably improved if there had been prior expert planning of the antenna farms and equipment installations, or by the employment of specially trained design-installation teams in the field.

Routine Communications

A thorough study of the best working frequencies for contacts with different parts of the antarctic or for contacts outside of the antarctic for various seasons and times of the day was not undertaken. Some generalizations were made on the basis of experience on communications with stations frequently contacted. Because of low interference and excellent radiation characteristics, 6708 kcs was phenomenally successful for communications with all antarctic stations up to 2,000 miles. The 4-mc frequencies with occasional shifts to 9 mcs were generally superior for year-round RATT operation between Little America and McMurdo. Tests around 20 mcs were conducted inconclusively between Little America and Balboa in June 1957, until the circuit was discontinued. ComNavUnits Antarctica directed McMurdo to continue them on a noninterference basis with normal operation and to report significant results.

On many occasions, communications were found to be spotty. It would be possible to copy one station but not a second at a given time, and then an hour later the situation would be reversed. Balboa reported being able to copy McMurdo and Little America radio teletype signals at times when the Balboa (50-kw) signal could not even be heard in the antarctic. At other times it was possible to copy Balboa perfectly when the antarctic signal was poorly received. On several occasions, it was possible for Little America to work Balboa when Balboa was working McMurdo, but it was impossible to work McMurdo from Little America. A considerable amount of traffic was passed between Little America and McMurdo via Balboa. It seemed that at one time or another all of the permutations of possible combinations of conditions actually occurred. Because of the frequent occurrence of these seeming inconsistencies, antarctic communications should be designed to operate with the utmost possible flexibility.

Blackouts

Communications blackouts are loosely defined, and are usually considered to be in effect in the antarctic when there is a loss of communications as a result of ionospheric or geomagnetic causes in approximately the 4- to 20-mc range. Blackouts are usually preceded and followed by brief or prolonged periods of unsettled propagation conditions, during which signals may be heard but the passage of traffic is only possible for short periods because of weak or widely fluctuating signal strengths. Blackouts do not affect ground-wave communications over short ranges of 5 to 15 miles, but they do seem to affect low-frequency communications over long distances. It was often noted that indications of geomagnetic disturbance would precede communications difficulties by 15 minutes to 2 hours. Ionosonde recorder indications usually only confirmed the presence of unsettled conditions.

In mid-May 1957, Little America attempted blackout propagation studies by advising McMurdo and Radio Balboa that Little America would transmit for the first 15 minutes of each hour on one of three frequencies (8975.5 , 6708, and 4703.5 kcs). Each frequency was employed once in every three-hour period. The frequencies selected comprised the widest range that crystallization of the 431D transmitter permitted. The goal was to determine if any systematic propagation patterns, as a function of frequency, could be determined for possible use in a general Antarctic Communications Blackout doctrine. Data from these tests were limited, but when combined with other observations they indicated that the ionospheric conditions change too rapidly and randomly to exploit opportunities for the expeditious selection of frequencies in the 4- to 16-mc range during disturbed conditions. It was determined, however, that a most profitable area of emphasis would be the re-establishment of communications in a minimum of (lost) time after propagation conditions would permit.

Therefore, on 30 September 1957, ComNavUnits Antarctica established a doctrine to be employed when any station missed two normal schedules on the Antarctic Common as a result of adverse ionospherics. All stations were directed to net-control (McMurdo) for 15 minutes on the hour every three hours. All stations were reminded to employ ship-shore circuits in an emergency. It is believed that this periodic coordinated attempt to regain contact maximized the likelihood for success. In addition, Little America and McMurdo were directed to monitor high, low and very low frequency fleet broadcasts, particularly Balboa's and report significant results. McMurdo was also directed to key 452 kcs for 15 minutes every three hours and Little America was directed to listen. These provisions were designed to uncover any characteristics which might not be found in routine operations and which might provide opportunities for more effective communications blackout procedures.

As a result of these tests, it was noted that LF and VLF signals below 45 kcs could be heard often at times when all other LF and HF signals were blacked out.

Interference

The sources of local interference from electrically operated equipment were minimized as quickly as possible and corrected whenever feasible. Interference from the weather broadcasts was annoying most of the time, particularly when propagation conditions were marginal. This situation should be improved considerably with the installation of more remote transmitting antennas and of dual-feed instead of single-feed antennas.

When hard winds with blowing snow were encountered, there was a resulting increased noise level in the receivers and there were occasional bursts of static caused by static discharge. This interference was increased when some of the transmitters were keyed, and it was noted also that the interference from the ionosode recorder pulses increased. This resulted in the operating procedure of securing the RATT transmitter after each transmission if the difference would materially assist reception and of employing different receiving antennas at times even though the gain was lower. The possibility of insulated receiving antennas should be considered for all antarctic communications installations. Rarely was it possible, however, to obtain frequencies with low outside interference. A relatively clear channel frequency for the Antarctic CW Common is sorely needed.

General Recommendations

The studies of monitored high, low and very low frequency broadcasts, especially Balboa's, should be undertaken and analyzed in a systematic and coherent manner in succeeding antarctic operations.

Since the operational readiness of naval activities in the antarctic depends upon superior communications, it is recommended that a comprehensive research program be undertaken in the field of antarctic communications, both long and short range, and that it be administered by an appropriate section of DNC or BuShips.

McMurdo

Two radiomen landed with the advanced party at McMurdo Sound on 20 December 1955. At Hut Point they established a temporary communications center in a two-man hut, using a hand-powered AN/GRC-9 transceiver. This unit was not powerful enough to establish voice contact with the task force ships which were approximately 60 miles north of the camp. Only vehicles in the immediate vicinity of the camp were in voice contact with the center. When an observation plane crashed, seriously injuring several men aboard, it was necessary for an R5D to go aloft to transmit a request to an icebreaker for medical assistance.

The installation of a TBW provided sporadic communications with the ships by late Christmas Day, 1955. Because of limitations of this unit and limited personnel at Hut Point, the task force ships guarded air-ground circuits. Although the signal output of the TBW was strong enough to be received upon occasions in New Zealand, local conditions prevented its receipt by weasels on the trail between shipside and the camp. One of the greatest inadequacies during this period was the inability of Hut Point to come up on a helicopter circuit. This condition and the lack of direct contact with vehicles on the trail hampered off-loading and trail operations.

By late January 1956, the temporary communications center was relocated at the site of the permanent camp. Two ten-man tents were jointed together, a plywood deck was built, a more reliable power source was provided, and a pot-bellied stove was added. Although the permanent communications building was erected early in February, an enormous task faced the small communications staff. The outfitting of the facility required complete checkage of all equipment prior to installation. One of the most difficult tasks was the erection of 14 antenna poles and installation of rhombics. McMurdo joined the Task Force communications network on 18 February 1956 and for the first time established contact with Little America.

Not until late March did the McMurdo radio fully assume its duties as communications control for the antarctic. Using the TBW, contact was made with primary stations of the world-wide naval communications system. As additional equipment became operational, the exchange of aerological data was begun. Initially, this service involved Weather Wellington and the two U. S. antarctic bases. Later, service was expanded to include three foreign stations in the antarctic - the Australian station, Mawson; the Russian station, Mirny; and the French station, Point Geologie.

Initial equipment installation was beset by equipment failures, a lack of test equipment, no stock system indentifying tubes and other components that were interchangeable in the wide variety of equipment, and an ever-increasing demand for manning more circuits.

The return of the aircraft in October 1956 created many problems. Aircraft communications contributed heavy circuit traffic and necessitated more frequent weather reports from existing and new sources. Further, the aircraft had UHF equipment installed and McMurdo was told by official message that certain UHF frequencies would be guarded. This was impossible since UHF gear was not on hand and none had been procured for Deep Freeze II. Press releases reached mountainous proportions. Although additional radiomen were flown into McMurdo for summer operations, there was a net increase of but two as wintering personnel were sent out with the satellite base construction parties. The equipment shortage was somewhat eased by the loan of equipment by the New Zealand Air Force.

During Deep Freeze II, a new transmitter building was constructed about a half mile from the camp. Because of the size of some of the new transmitters it was necessary to construct the building around them. The existing Communications Building was altered to become a receiver building and communications central. Also, a new transmitting antenna field was erected.

One big problem encountered with the transmission lines was the standoff insulators used. They would not support the copperweld cable for any distance. The vibration and sway of the lines from the wind coupled with the strain from the weight of the copperweld snapped the insulators. A blizzard blew down 800 feet of power cable and 1000 feet of transmission lines. Because of a lack of standoff insulators, the transmission lines were reinstalled by stapling them to the crossarms. Although it was questionable whether this scheme of attaching the lines would withstand blizzards, no loss was noted after the next storm. However, the storm did part the messenger on the keying lines and the power line at several places. The power line was also blown off several poles. In repairing the cables, they were removed from the poles and layed on the ground.

Conclusions

Communications in the antarctic are not really any different from communications anywhere else in the world. One certainly cannot get by on less equipment and personnel. The equipment and personnel necessary during the winter phase of operations cannot hope to serve all the ships, planes and press that arrive with summer operations. The needs of aerology and the press are so extensive that an entirely separate unit might be justified for their use.

Ionospheric conditions and the local weather situation at McMurdo frequently limited circuit time and necessitated relay to or through other stations. Under blizzard conditions, static electricity built up on antennae, causing considerable arching in the transmitters, and frequently necessitating shutdown of the equipment. The attachment of grounded coils to the transmission lines bled off the static charge and solved this problem. High winds and blowing snow produced a high noise level.

One of the greatest deterrents to efficient operation was the condition in which the equipment was received. The equipment had not been inspected or tested prior to employment. The wide variety of types of equipment allocated for the same purposes made for a complex maintenance problem and unnecessarily increased the number of spare parts stocked. The lack of a stock control and identification system further aggravated the situation. Standardization of receivers and transmitters would reduce the spare parts requirements and decrease the complexities of maintenance.

The average radioman assigned to Deep Freeze I did not have an adequate background in communications, which is not a reflection upon the personnel assigned. There was an obvious lack of familiarity with the various pieces of equipment and of proficiency in operation by the lower rated personnel, particularly in receiving and transmitting coded weather data. Some operators were not familiar with testing and maintaining equipment, which placed an added burden on those who were qualified. They were called upon not only to work with naval ships and stations, but also to work with stations of foreign nations employing commercial operators of large communications.

Recommendations

1. That during the pioneer phase of future cold-weather operations a wanigan be outfitted as a communications center. It could be equipped with two TCS transmitters or a newer comparable model, a VHF transmitter, an independent power supply, a heating unit, one operating position, a tube tester, and a minimum of spare parts and maintenance equipment. After the permanent facilities are completed, the wanigan could be utilized for aerological communications, trail operations, or use at a satellite base.

2. That radio equipment be standardized and spares cataloged. All equipment should be checked and operationally tested prior to shipment to the antarctic.

3. That radiomen be carefully screened and schooled in the operation, test and maintenance of the equipment to be encountered. They should be

familiar with commercial procedures and with teletype equipment and procedures and should be proficient in voice and CW transmissions. It is desirable that operators be able to copy at least 20 words per minute in CW operations. Personnel assigned to small bases will be assigned considerably more responsibility and be required to perform a greater variety of tasks, with much more limited facilities.

4. That UHF equipment be authorized and installed at McMurdo to expedite aircraft circuit guarding.

5. That heavy armored ground cable or proper aerial cable be procured for Deep Freeze III as a replacement for the present power cable.

6. That shorter insulators be procured for the transmissions lines.

7. That a more durable type of antenna mast be used. Perhaps one of aluminum or light angle iron.

Little America

Considerable local interference was caused by the proximity of transformers to receivers and of transmitting antennas to receiving antennas. This interference was minimized by using various combinations of antennas. Another interference to communications was most of the camp's electrical appliances, such as adding machines, barber clippers, carpenter shop tools, and mess hall and sick bay equipment. At times when incoming signals were weak, it was impossible to work the circuit and the source of interference had to be secured.

During the fall months the McMurdo-Little America point-to-point circuit operated nicely. Traffic was moderate and signals were good for about 17 hours daily. Signals dropped almost completely out from midnight to about 8 a. m. During the winter and early spring, traffic increased twofold. No difficulties in handling traffic were encountered until additional stations were inserted on net. Upon the return of the ships and upon activation of Beardmore, Byrd Station and South Pole Station, the stations were included on the McMurdo-Little America point-to-point circuit. This hampered traffic-handling but was the only way to maintain communication with the newly formed activities.

Signals from Cape Hallett varied from fair to good. Beardmore was fair on most of their skeds with McMurdo. When the South Pole station was using the TBW, signals were fair. Great improvement was noted when the 30K5 went on the air. Few skeds were maintained with Byrd Station as serious fading was encountered on most of the schedules.

During the period from February 1956 through February 1957, two lengthy communications blackouts were observed. These two outages averaged about 70 hours each. The initial long outage occurred in March. All bands were completely dead. Only VLF bands showed any indication of signals. The second long outage, in February 1957, appeared to be only a local condition. Communication with McMurdo was severed but both Little America and McMurdo were in communication with Balboa. Traffic to and from McMurdo was relayed via Balboa. There were several other outages of from 8 to 30 hours duration.

Equipment for air/ground circuit control at Little America was installed in the Electronics Building at Kiel Field. All equipment other than standby equipment was operated on normal aircraft frequencies. The standby equipment, due to its not being pretuned and channelized, was used on emergency guard frequencies only. All antennas were on the roof of the Electronics Building and control tower. The ART-13, ARR-15, and primary ARC-2 used a 35-foot mast. The secondary ARC-2 used a 16-foot whip.

Communications varied greatly with atmospheric conditions. On good days it was possible to communicate with aircraft on the deck at McMurdo with the low-power ARC-2. On other days, the higher powered ART-13 would only carry 75 miles. Communications improved after the selenium rectifier replaced the motor generators as a power supply. The aircraft radio equipment proved very satisfactory for tower use due to its channelization and the fact that supply is simplified by interchangeability with aircraft spares. The BuShips gear (115-V, 60 cycles) is good because of the reduced noise factor; however, its lack of channelization limits it for tower use.

It is felt that communications as a whole worked out very well considering the lack of a proper ground and the fact that the antennas, of necessity, were close together. Kiel Field handled most of the aircraft position reports in addition to normal tower traffic. Occasionally traffic had to be relayed through the more powerful transmitters, more sensitive receivers, and superior antenna field of Little America.

As a result of the increase in the equipment allowance, the communications installation at Little America was completely revised during Deep Freeze II. Critical shortages appeared in spare parts and antenna materials. Many essential antenna materials were procured from Little America III by air.

By mid-March 1957 it was apparent at Little America that the 500-watt TBM transmitters were underpowered for complete antarctic coverage on an omni-directional broadcast (even when employing directional antennas to emphasize the desired areas). The antennas were designed and

constructed for 6 and 12 mcs. CNO later assigned additional frequencies in the 4-, 8-, 12- and 17-mcs ranges. It was apparent that the 8-mc frequency was the most satisfactory for reception by the U. S. bases, but that the 12- or 17-mc frequencies had more promise for Ellsworth Station during certain hours.

Transmissions on three frequencies simultaneously commenced late in June, when the 17-mc frequency was added to the 4- and 12-mc frequencies. Although thoroughly conclusive data is not available, it is believed that the additional frequency was successfully received by some stations. In July the new 6-mc frequency replaced the former 4-mc frequency, and no further changes in the broadcast frequencies were made after that date. The 6-mc frequency was highly successful, appearing to be received better than either the 4- or 8-mc.

In early August it had been verified that the Little America broadcast was not covering the continent. A plan for increasing the power output of the TBL transmitter from 250 to about 1400 watts by utilizing the power supply of the 2-kw TAB low-frequency transmitter was approved with the provision that all safety precautions would be observed and that the time required to return both the TBL and the TAB back to their normal operation would not exceed one hour. (This was to provide Kiel Field with a low-frequency homer backup.) Although the measures taken to improve the broadcast were admittedly of a limited nature, they were the only ones available and did succeed in effecting an improvement.

The performance of trail communications varied considerably in the several applications employed at Little America, and, except for a few obvious considerations, the reasons for success or failure are not completely ascertained. On one Byrd tractor train operation the TCE transmitter collapsed from structural weakness under the vibrations and jolts encountered in the wanigan. For communications over 5 to 10 miles, the AN/GRC-9 does not have enough power. The TCE and TBW transmitters employing 115-V ac motor generator power supplies were excessively noisy when receiving. The TCS transceiver employed on the IGY traverse October 1957 performed very well but indicated a receiving weakness since its 40-w signal was better received at Little America than either of Little America's 500-w TBM's or the 30K5 were received by the traverse.

The most successful tractor train communications were experienced in October and November 1957. The equipment utilized was a TBW5 Transmitter, using the Magnetic Controller, 120-v ac M/G power supply, rectified modulator and HF units of the transmitter. The receiver was a RBM5 with the 110-120-v ac power supply. The antenna installation was made with the aim of being able to transmit while underway. A 15-foot whip antenna was installed and connected to the transmitter and the receiver by 52-ohm coaxial cable. The frequency used was 6835 kc. It proved to be highly

acceptable for the entire distance of 643 miles. CW communications were highly reliable at all times and good voice communications were maintained at a distance of 580 miles. The only difficulty ever experienced in voice communications was during heavy storms when movement of the whip antenna caused some fading at both stations and at close distances from the base (about 20 miles). Generator noises often necessitated shutting down the transmitter and generator while receiving, and required over four-fifths of the available power for starting and three-fifths while operating. This precluded the use of some other electrical equipment in the wanigan when transmitting.

If power were to fail, or a fire were to destroy the communications capability at Little America, the Kiel Field installation a mile and a half away was available for primary emergency use. It was possible for Kiel Field to operate on two high frequencies at once with satisfactory receipt at McMurdo. A battery-powered phone line from Little America to Kiel Field provided a rapid means for notification in the event of disaster. Secondary emergency communications up to 100 watts were available in vehicles or wanigans.

Recommendation

A more extensive and liberal spares analysis should be made by technicians familiar with the equipment. It is believed that the Section "R" allowance lists used on Deep Freeze I were obsolete. Also, the Section "R" allowance lists were designed for units with resupply readily available.

Byrd

From 5 January 1957 Byrd Station's radio shack was in full operation. Byrd Station's primary outlet for traffic was Little America on the Mother-Daughter IGY Net. On occasions, when traffic could not be cleared through the regular circuit, Byrd Station came up on the U. S. Antarctic Common and passed traffic through McMurdo. Usually conditions on both circuits were quite close so in cases of bad conditions very little was gained by changing circuits. The quality of operators on the common, especially at the net control station, slowed traffic considerably by misuse of precedence, lack of circuit discipline, and generally poor circuit control.

Throughout the year a seemingly excessive amount of administrative traffic had to be handled. Most aggravating of these were General Messages, such as ALLANTFLTS, requesting we turn in excess lots of 5/38 MTF to the nearest depot, etc. During the period from 5 January to 1 November 1957 no toll traffic was handled. Due to excellent CW Hamgram facilities, class Echo traffic was discouraged. As no press representatives were present at Byrd, no class Delta was necessary.

The Byrd IGY traverse party was equipped with three AN/GRC-9 radios, using long wire antennas for distance and whips for inter-vehicle communications. In February 1957 the traverse enroute to Byrd from Little America was heard working Little America (voice) at distances in excess of 500 miles. Early traverse communications were unreliable and no CW operator was with the party. Through the winter, members of the traverse learned Morse code and became quite proficient. The traverse left Byrd Station again in October 1957, using the same gear. Voice communication was reliable up to 100 miles. After that distance CW was used satisfactorily. The second and third tractor trains (January and October 1957) both used Little America as a control point for communications, although Byrd monitored nearly all schedules, relaying as necessary. Reception of both trains was equally good within a 400-mile range.

On 5 October 1957 work was received via ham radio of the launching and frequency of the USSR earth satellite, Sputnick #1. Immediately a receiver was tuned to 2000.5 kcs and a "beeping" signal was picked up. This was determined to be the correct one and recording commenced on the 6th of October. Due to shortage of tapes, only one complete orbit of the satellite was taped. This was with time intervals spoken onto the tape. On 8 October the signal could no longer be heard on 2000.5 kcs, and as no equipment was available for 40 mcs, tracking was discontinued.

Byrd Station observed many interesting phenomena in communications. The station seems to be located in a highly receptive area, with much "one-way skip." The most interesting of the phenomena was a total blackout, a period of outage with no signals present on the entire spectrum. A total of 6 blackouts of over 24 hours were experienced, the longest one being 141 hours, from 29 August to 4 September. The average monthly outage due to blackout conditions was 94 hours, the heaviest in September, the lightest in May. The most erratic conditions seemed to be during the light and dark transition periods.

All blackouts began and ended in the same manner, with the low end of the band going out first and coming back in last. Blackouts were always preceded by at least 24 hours of extremely good conditions, followed by a period of high noise level with local interference increasing sharply. Throughout the year no correlation was apparent between the condition of the ionosphere and intercontinental communications. Most periods of erratic and difficult conditions were closely related to heavy geomagnetic disturbances. A secondary cause of outage was from snow static, a result of winds blowing dry snow against or past antennas and guy wires. Twenty knots of wind caused difficulty; over 30 knots of winds made communications impossible. At one time during a 60-knot-plus wind, a charge of 1000 volts was measured across the whip antenna terminals. By burying antennas, a sharp reduction was obtained, but a charge was still present. An increase in height of antenna poles (over

60 feet) caused an even sharper reduction, as this placed the antenna above the blowing snow, but a charge was still present on transmission lines. Occasionally some interference was noted from aurora flutter, but never enough to block reception.

The most effective way of judging radio propagation in the antarctic interior is with the amateur radio, due to longer and wider range of localities worked. The condition of the ionosphere closely paralleled that of the "ham band." Approximately 30 minutes after disappearance of all layers, reception was lost; however, our signal was heard in the U. S. for another 30 minutes. This condition was verified several times, sending Hamgram traffic in the blind, after contact was lost.

For intracontinental operating, 6 to 8 mc were the most reliable between Byrd and Little America, 8 to 10 between Byrd and McMurdo. Low frequencies proved useless for Naval Communications with the exception of Homing, which was unreliable at the best. Low frequency with high power is not recommended for antarctic interior stations.

Emergency communications equipment consisted of one AN/GRC-9 mounted in a weasel. Four AN/PRC-6 transceivers (handie-talkie) were also available, but of limited use.

Comments and Recommendations

Under normal winter conditions, two radiomen were sufficient for Byrd Station, although a third would have been very useful. Due to the size of the station each man must assume one or more collateral duties, such as movie operator, I&E officer, ships' store assistant, etc. One solution which would also provide necessary assistance during the period of heavy workload in summer, would be to replace the ET with an additional RM.

All experimentation was curtailed due to lack of supplies and equipm. c, but some type of program for the RMs could be valuable to the Navy as well as useful for morale.

Teletype equipment would be desirable for any stations that might be permanent. If receive-side teletype is installed, send-side should also be included, as the material requirements for send/receive teletype would be only slightly more than for receive only.

South Pole

The communications utilized during the initial phases of the South Pole Station establishment consisted of one AN/GRC-9 transceiver mounted in a weasel and one hand-cranked AN/GRC-9 as a spare. No difficulty was experienced normally in making CW contacts with the Beardmore Base, approximately 325 miles from the Pole. Occasionally McMurdo, 730 miles away was contacted on CW. Most of the time a short whip antenna was used; a few times a long wire was used.

As Jamesway #1 was erected, two TBW trans-receivers were set up, but because of initial power limitations only one could be used at a time. The low-frequency bay of the TBW was tuned to 510 kcs as an aircraft homer. However, it was never effective. The 6-mcs frequency was usable from 0600 to 1200 GMT, and the 8-mcs frequency was a little better as it came in earlier and went out later. For air guard communications with aircraft within visibility, a PRNC-17A battery-operated walkie-talkie unit was used at first. On VHF it was used to transmit landing instructions at the field and in drop control. The UHF was used as a homer although it had very limited capabilities. When 28-volt power became available, an ARC-1 gave excellent positive air/ground communications within a 10- to 15-mile radius. Since batteries are very much reduced in power by the cold, a battery-operated unit is not desirable if other arrangements can be made.

The permanent gear was installed in the mess hall. The receivers consisted of three Collins 51J4 and one Collins 75A4. The transmitters were two Collins 30K5. The antenna field poles were erected prior to 4 January 1957, but the wire had to be strung by the wintering party. The wintering party also planned to erect another whip 27.5 feet long.

The traffic load at the Pole station averaged six hundred messages a month. The incoming and outgoing administrative traffic was handled mostly on a scheduled basis. The operational commitment placed on the station was by far beyond the capabilities of the one radioman. The normal communications traffic load was doubled during the summer months of operations. During this time, there seemed to be an excess of administrative traffic (ALLANTFLT's) that did not apply in any way to antarctic stations.

Messages from the South Pole Station were normally transmitted to McMurdo for relay. A few were transmitted to Little America for relay to McMurdo during times of radio blackout with McMurdo.

The minimum complement for this station or any other station of this size and type should be two Radiomen and one Electronics Technician. The Electronics Technician and at least one Radioman should be first class, the other Radioman second or third class.

Propagation and interference patterns seemed to be bi-seasonal. Rather radical changes and conditions would be experienced during the equinox period. Some interference was noted from other Navy stations using the same frequencies (in the 8- to 9-mc region). These stations were located in the Hawaiian Islands and Nova Scotia. Interference from South American stations was encountered at times but did not cause a great problem. Reception of Scandinavian and Russian radio was commonplace.

Local interference was experienced with high winds, which caused precipitation static. Also a very intense aurora display would cause interference. This would be associated with a very definite magnetic disturbance. Man-made interference was kept to a minimum.

The lower limit of any radio signal heard was between two and three mcs; 30 to 35 mcs were about the upper boundaries for radio signals. The Antarctic Common, 9001 kcs, was a very good frequency for CW communications. Both 6708 kcs, the air-to-ground primary, and 8975.5 kcs were used with very good results through the summer and winter between other stations and the Pole for voice communications.

Recommendations

1. The overall communications system down to the selection of each station's equipment should be the responsibility of the Bureau of Ships, not the Task Force.

2. Identical and similar equipment could and should be placed at each and all stations in the system, thereby lessening the very complex supply problem by giving these stations the capability to help each other out: TDO and TDH transmitters for McMurdo and Little America; TDO transmitters for the Pole, Byrd and Hallett stations; 51J-4 receivers and URN-5 low-frequency homing equipment for each station. In this manner all spare parts, components, units and equipment would be common to each other station as well as on each station.

3. A powerful UHF transmitter should be provided the Pole Station for future operations. As navigation is a very realistic problem on the Plateau, a reliable homer is a necessity.

<u>Hallett</u>

Communications commitments were far in excess of personnel and equipment capabilities. Available was one transmitter and one Radioman. Equipment and personnel requirements were not planned with an eye to communications commitments. This disadvantage has been somewhat augmented for Deep Freeze III by the addition of another transmitter and another Radioman.

The Antarctic Common circuit was scarcely adequate due to congestion of stations and, on several occasions, to inexperienced operators at McMurdo. The frequencies available proved adequate insofar as propagation is concerned.

Generally, Hallett is situated in a position that is ideal for propagation for the stations operated. As a rule, communications with New Zealand was a case of all or nothing. Signal strength both ways was

nearly always QSA4 to 5. During ionospheric blackouts, this was the last circuit to be affected and usually the first to return to operation. Propagation between Hallett and McMurdo was generally good to excellent. Few serious blackouts occurred during the period of darkness. The period of greatest ionospheric disturbance and total communications blackouts was during the summer months. During November and December 1957, Antarctic Common was usable only about 12 hours per day due to frequency transitions and insufficient frequencies being available for continuous communications.

Interference was by far the most serious difficulty encountered on the Antarctic Common circuit. Both 8975.5 and 9001 kcs were seriously interfered with by CW and RATT signals. The Air/Ground common frequency 6708 kcs was excellent propagation-wise and entirely free from interference. Little difficulty was encountered on commercial New Zealand circuits. The most serious form of interference, affecting all communications, was caused by the ionosonde. This device radiated such strong interference as to block entirely all incoming signals. Communications were most seriously disrupted during days when the ionosonde was sounded at five-minute intervals. This interference was reduced somewhat by employing a 35-foot whip antenna for receiving, though still leaving much to be desired. Very little interference was encountered due to electrical devices such as motors, relays, etc.

Recommendations

1. In an operation of this scope, it is needless to say that careful planning should go into personnel and equipment requirements. However, a lack of such planning to a sufficient degree has been noted in the case of Cape Hallett Station. It would appear that personnel and equipment requirements were planned with the size of the station in view, rather than by the more important consideration of operational requirements. For example: personnel strength at Hallett, 14 men; personnel strength at Wilkes, 28 men. Hallett was provided with one reliable transmitter and one radio operator. Wilkes was provided with two each. However, operational requirements for Hallett were likely twice as great as those for Wilkes Station.

Since a radio operator is one of the station's key personnel he should not be placed in a position making him indispensable. Therefore, it is strongly recommended for future planning, no matter how small the requirements may be, to have a minimum of two radio operators at each base.

2. Poor liaison between New Zealand and U. S. governments was very evident at the outset of the Operation Deep Freeze II wintering-over period. This was made more evident when commercial NZ radio circuits were activated in April with no prior cognizance on the part of the wintering-over group.

In order to augment better communications it is recommended that a system be set up for primary and secondary means of communications for Antarctic Common Circuit. During propagation difficulties, it would best serve all stations if both McMurdo and Little America kept a guard on Antarctic Common, McMurdo guarding the primary frequency in the vicinity of 8 or 9 mcs, and Little America guarding the secondary which could be around 6 or 7 mcs. Experience has shown that this arrangement would provide more reliable communications. In the event communications could not be established with primary Antarctic Common, traffic could in all probability be cleared on secondary. As an alternative, personnel and equipment permitting, McMurdo could guard both frequencies.

3. From the standpoint of antenna systems and reduction of interference, it would be most desirable that communications be placed in a separate building by itself. This building should be large enough to house an electronic workshop and storage space for spare parts.

Wilkes

The bulk of administrative and operational traffic was handled on the Antarctic CW Common Net on a scheduled basis. The estimated average monthly traffic was about seven hundred messages. Wilkes sometimes acted as a relay station for other U. S. antarctic stations during times of disturbed radio conditions. Traffic during the short summer resupply period almost doubled from the relaying of ships' traffic.

Local trail party communications were normally handled on a scheduled basis. However, during times that trail parties were in the field a continuous speaker watch was maintained until the destination was reached or until their return to base. As many as four trail parties would sometimes be in the field at the same time. Wilkes Icecap Station communications were normally conducted on the trail party frequency once daily.

Air/ground communications were for all practical purposes nonexistent. During the very brief summer resupply period VHF voice communications were conducted with ship's helicopters.

A summary of communication operation for April through November 1957 shows six radio blackouts of over 24 hours duration. The most severe month for radio blackouts was September, followed in severity by April and October. The blackouts corresponded very closely with ionosonde records for the same periods. The above observations were made on the Antarctic CW Common circuit. However, it was noted that the amateur radio bands generally followed the same pattern. VHF performance appeared unaffected by radio blackouts.

Blowing snow and low cloud cover would often cause heavy precipitation static. This would cause a high electrical charge on all longwire antennas with subsequent arcing discharges to ground, making reception of radio signals difficult. Interference from Russian, South African, and Navy stations located in South America were experienced on the Antarctic CW Common circuit. At times it was so severe it slowed delivery of traffic.

A Navy Model MM semiportable radio was installed in a Jamesway hut 800 feet from the main base to provide emergency communications. A 1-1/2 wavelength longwire antenna was installed. This equipment supplied adequate emergency communication, however, the gas engine generator supplied as a power source is considered obsolete and should be redesigned. The carburetor had a strong tendency to ice up and unshielded ignition wiring was a prolific source of radio interference. If these two defects could be overcome the equipment would be adequate for the use for which it was designed.

Recommendations

1. The minimum complement for this station should be one RM, one RM3 and one ET3.

2. Similar future installations should be equipped with wire guys broken at appropriate intervals by suitable strain insulators.

3. A rigid effort should be made to screen reclaimed defective components from the supply system. If their use is necessary as an economy measure, they should be issued to rear echelon areas and never to forward operating areas.

Ellsworth

Ellsworth's primary outlet for traffic was McMurdo on the Antarctic Common. At most times signal conditions were poor and interference great. The Antarctic Common was used by all U. S. antarctic bases except Byrd and Little America stations for clearing administrative and weather traffic. The number of high-precedence weather messages made it extremely difficult to clear low-precedence administrative traffic. Also, the procedure of clearing all traffic of one-operator stations first slowed down traffic of higher precedence for all stations.

The frequencies (8975.5 and 9001 kcs) employed as Antarctic Common were too low for operation with Ellsworth. Total darkness or total daylight in the antarctic had very little effect on radio communication at Ellsworth. During periods of blackout on the Antarctic Common the policy was to call Naval Radio Station, Balboa, on the ship/shore nets and arrange for a schedule on one of the antarctic point-to-point frequencies. Contacts with Balboa were generally good when operating on frequencies in the 8-, 12- and 17-mcs ranges.

Communication for the traverse party was furnished by an AN/GRC-9 receiver-transmitter unit. A TRW unit had been planned, but the change was made due to weight limitations in Sno-Cats and the fact that this transmitter had been installed as emergency radio for the base. The AN/GRC-9 proved reliable up to 150 miles, but beyond that it was very unreliable. Communication was lost with the traverse party for about twenty days until it was possible to fly out a different transmitter. A URT-11 (100-w CW) transmitter was procured from the Air Force and sent to the traverse party. After installing this unit, communication was back to a daily schedule. A member of the traverse party should be able to copy CW as the range is greater and interference does not make it as hard to copy as voice.

Air/ground communications were mainly handled by AirDevRon Six personnel. Due to their low-power equipment any flight over 100 miles had to be handled by Radio Central. With only one operator on watch this meant securing or standing listening watches on most of the other circuits.

The traffic load for Ellsworth was heavy and could have been reduced by proper screening of general messages at McMurdo. Class Echo traffic was handled by Navy circuits the entire year, but after the amateur radio was in operation they were discouraged except in cases of emergencies. Press releases (500 to 1500 words) were sent to McMurdo for relay to CHINFO. The length of these releases for manual CW sometime tied up the circuit for hours, causing other traffic on the circuit to be delayed.

Ionospheric conditions at this station made communication with McMurdo extremely difficult. During 1957, August was the only month when there was not a total blackout of several days with McMurdo. The average for blackouts was 7 to 10 days per month. Of interest is the fact that even though the Antarctic Common (9001 kcs) was blacked out, McMurdo could and was worked by amateur radio on the twenty (14200 to 14300 kcs) and the fifteen (21300 to 21430 kcs) meter band. This point was brought to the attention of McMurdo but they said it was impossible for them to shift their transmitter off the Antarctic Common (9001 kcs). There was only a period of a few hours daily when we could not contact the Pole Station on the Antarctic Common. During these blackouts the Little America-Byrd Station circuit was utilized when possible, with fair results. At times when conditions were bad, the geomagnetic recorder showed traces of magnetic disturbances. This was not true with the ionospheric recorder, which would show total absorption at times when the conditions for communications were at their best. Base interference was kept at a minimum. A minor source of interference was snow static. Emergency radio was set up in a Jamesway hut located 300 yards from the main camp. The equipment consisted of a TBW (125-w CW, 75-w voice) transmitter, RBM receiver (HF and IF), motor generator, portable 1-kw gas-driven generator, semi-portable 5-kw gas-driven generator and an AN/GRC-9 receiver-transmitter unit.

Recommendations

1. It is believed that, with construction of a rhombic antenna beamed on McMurdo, communication for Ellsworth/McMurdo will be greatly improved.

2. We recommend three radiomen for stations having an air group aboard.

3. Teletype equipment should be sent to outlying stations. If impracticable for transmitting teletype equipment to be sent, a receiver unit would help greatly to clear incoming back-logged traffic after blackouts.

AMATEUR RADIO

McMurdo

Operations of amateur radio stations KC4USA, Little America, and KC4USV, McMurdo Sound, were in most respects quite similar. The main difference was in the number of operating personnel. McMurdo Sound relied mainly on a Chief Radioman, while Little America had a five-section watch. Both stations considered their system the best and there is no doubt that both had distinct advantages. The location of the ham shack at McMurdo was in the main communications building. Mutual interference many times interrupted ham operation, while at Little America, with the ham shack located in a separate area, there were no such problems.

Both stations used a KWS-1 1-kw transmitter. McMurdo's transmitter fed into a stationary beam antenna elevated about 20 feet above the ground. Both antenna and transmitter have been relocated at McMurdo Sound and operation is more successful. Operation at McMurdo commenced on 17 April 1956. During the first 13 days of operation, 291 CW contacts were made. Using the 20-meter band, it was found that only the late afternoon and evening could be utilized for making contacts, as during other periods the band was dead. It was also found that scheduling of contacts was not feasible as once again conditions were so uncertain that the chances of meeting such a schedule were small. The majority of hams contacted in the early days of the operation were unaware of communications conditions in the South Polar areas and complaints were often heard that one or both stations in the antarctic often appeared to just "throw the switch" without warning.

The first phone patch was made in May and from then on this was the main means of operation as it afforded a more desirable, although at times a far less reliable, means of communication. As operations continued,

many of the hams, content with a QSL card from the antarctic, dropped out and the band quieted down enough to allow more satisfactory means of traffic exchange. It soon became apparent that certain hams in the United States were old standbys and could be counted on almost any evening to be standing by to pass traffic or give us the latest news.

During the course of the winter, there were occasions when Navy communications were so overtaxed because of the heavy traffic load or nonavailability of equipment that it was deemed necessary to use the ham bands for voice conferences with Little America. There is no doubt that much can be accomplished through voice discussions between persons wintering-over and by the men who are supporting or relieving them. Unfortunately the provisions under which the amateur radio operators work do not allow for semi-official use of the amateur bands. Provisions for this type of operation would have to be arranged well in advance. The assignment of several frequencies close to the 15- and 20-meter amateur bands would enable the amateur equipment to be used on Navy circuits, should the need arise.

The amateur equipment at McMurdo almost exclusively used the 20-meter band during the first five months of operation. During the winter months very few readable signals were heard on the 15-meter band, the only other band considered. However, with the return of daylight, the 15-meter band did open up and operations were conducted on those frequencies.

Amateur radio in the antarctic can often be a headache as well as a benefit to all personnel. Operations during the summer cannot be governed by the same policy used in the winter, as the influx of transient personnel does not allow for this. Of course, with the frequent mail service that summer brings there is not the pressure to "talk home" and so the situation as a morale issue is not as acute. Each station must have its own policy designed to answer the individual problems of each base and operators. Close adherence to the rules which govern amateur operators and the realization that although operated by naval personnel, the operator is working a world of hams will do much to continue successful operation of amateur radio in the antarctic.

Little America

In 1957, over 1700 phone patches and 4000 hamgrams were handled at Little America. Under the supervision of two radiomen, a team of up to eight IGY and Navy personnel maintained continuous amateur radio operation whenever propagation conditions permitted. As in Deep Freeze I, the best times for contact with the States were between 0100 and 1200Z. The 20-meter band was used most of the time and the 15-meter band at times in the antarctic summer. During the months surrounding sunrise and sunset, amateur radio experienced the same difficulties in propagation conditions that were found in the official communications.

The equipment employed, Collins KWS-1 and 75A4, was among the finest available. There was a shortage of tubes, but careful operation resulted in better than expected tube life. In Deep Freeze II the ham shack was relocated to the recreation building. The antenna was a rhombic beamed at central United States to produce the greatest possible coverage of the country. The output of the transmitter was matched to the rhombic by means of a Collins exponential balun. The balun caused considerable difficulty by opening under the tension caused by the weight of the drifted snow on the coaxial side of the transmission line and possibly by the extreme temperature changes. Such installations should be made with plenty of slack cable where drifting can occur.

Three aspects of the amateur regulations were initially unclear from the information in the available directives and the Task Force Communications Plan:

1. Inquiries from several of the bases indicated that private gear had been brought to the antarctic and that the relationship with the operation of the base equipment was in doubt. The bases were advised by ComNavUnits Antarctica that the OINCs were in control of all amateur operations at their bases, that all amateur equipment at each base would employ the base call sign, that the operation of amateur equipment could be authorized by the OINCs for qualified non-licensed personnel, that all transmissions must remain within the international ham bands, and that all equipment must be employed primarily for base morale purposes for all hands on an equal basis. It is recommended that these matters be included in future OP Orders.

At Little America, private equipment was employed for CW, and Navy equipment was employed for voice transmissions. All hamgram traffic over the Navy equipment was passed via the RAGS in Syracuse, while the private gear was used for the exchange of hamgrams through other stations in the States. This arrangement was entirely satisfactory. For Deep Freeze III, the use of a personal call sign was authorized at Hallett Station by one of the New Zealand civilian personnel. The use of personal call signs by U. S. personnel in the antarctic using personal and/or Navy gear should be considered and the decision included in future OP Orders since this question is posed annually.

2. Initially, except for the auxiliary TBW transmitters, Wilkes and Hallett bases were not equipped with official Navy transmitters adequate for long-range voice communications. Later in the year, through the ingenious utilization of base intercom spare parts, they were able to employ their TBL transmitters for voice transmissions. Voice operation was still severely limited because of the obsolete equipment. As a result, these bases were equipped with only the 1000-w amateur gear for satisfactory voice operation. In a resounding chorus, the scientists demanded authority to employ the amateur gear for the exchange of

scientific information, and received it in early May with the stipulation that it be conducted with a minimum of interference with the primary morale use of the equipment.

3. By early April, Little America had received several requests by professional news media representatives to interview personnel in Antarctica via amateur radio. The rest of the antarctic stations indicated that they, too, had received requests for information. On 20 August the authority was received subject to compliance with FCC amateur radio regulations.

Several times during the year, the voices of the family of the Russian observer at Little America were transmitted over Radio Moscow. Before each occasion, Mirny notified Little America and the broadcasts were tape-recorded for the Russian observer, who was most appreciative. An attempt was made to procure tape recordings of the family of the American observer at Mirny. After a considerable delay a tape was obtained from the family and transmitted to Little America. But the quality of the tape was only fair to begin with, and the quality deteriorated somewhat on the relay to Little America even though several attempts were made to utilize optimum conditions. It was never possible to get a run of it to Mirny that was successfully readable. Upon the departure of Deep Freeze II personnel from the antarctic, steps were taken to recommend that arrangements be made with AFRS or Voice of America for a better try the following year.

Recommendations

1. It is recommended that Collins phone patch equipment be considered for the antarctic bases, so that a private booth could be provided and yet permit monitoring of the patch by the operator. This should also make it possible for patches to be run from remote parts of the base through the ham station when storm conditions or time and distance do not permit easy access.

2. Since Antarctica is, as yet, an unclaimed continent as far as U. S. foreign policy is concerned, it is recommended that the possibility of specifying that the operation of the amateur facilities at the U. S. stations will be solely under the jurisdiction of the Area Commander be considered. This would permit the unrestricted use of all internationally designated amateur frequencies. It is also recommended that background information concerning the licensing of the stations be provided the bases or included in future OP Plans.

3. In November 1957, when the station operators were faced with mailing the QSL cards they had amassed during the winter night, the authority to use Navy franking on them was requested inasmuch as they represented a means of thanking amateurs in the States for assisting in

the maintenance of morale through the amateur contacts. The request was refused. It is recommended, however, that the matter be brought up again in the light of the fact that the antarctic amateur radio stations, in falling under the direct control of the OINCs and in using Navy amateur call signs, become official Navy activities, in the same sense that Navy special services activities are official and qualify for the use of Navy franking on associated correspondence.

Byrd

The amateur radio (Station KC4USB) was installed in the mess hall by Deep Freeze I personnel. The transmitter was a Collins KWS-1 and the receiver a Collins 75A4. Power was adequate in all respects. The only precaution taken was to secure all high voltage prior to shifting generators, leaving only the filiment voltage on.

The ham rig was placed in operation 5 January 1957 by members of the construction crew. The set was not in a desirable shape, having been used at Little America through Deep Freeze I. The set was operated on 20-meter (14 mcs) throughout the first summer and winter, almost exclusively on single side band. Phone patches were obtained for a majority of men; most were of poor quality and some men did not have any at all. This was due in part to sections of the U. S. being hard to get into, due to the time element, etc. Through the winter months, voice communications was undependable and most hamgram traffic was handled by CW.

South Pole

Amateur radio provided almost daily contact with the United States, throughout the year in the 14-mc band and during the summer months only in the 21-mc region. Foreign and U. S. territories were contacted mainly during the antarctic summer, with no contacts made to Hawaii, New Zealand or Australia during the winter.

A Collins KWS-1 transmitter was provided. This is a very nice piece of equipment. At the same time this called for much more maintenance than any other piece of equipment on the station. It also received many times more use than any other equipment. Two 75A4 Collins receivers were used exclusively for amateur radio with excellent reliability. The ham radio shack was located at one end of the radio room in the building which also housed the mess hall and meteorology.

Hallett

Amateur facilities were more than adequate to meet the needs of the ten men using this privilege, and proved 90-percent efficient. Each man so desiring made phone patches home on the average of one every two weeks, and more in some cases. Hamgram services were excellent, and satisfied the needs of everyone concerned. In general, quantity and quality of phone patches and hamgram messages was sufficient to meet morale needs.

A Collins KWS-1 transmitter was initially installed in the communications shack. Operation was full power (1-kw) using a VEE beam antenna with shorted matching stub. Interference between official communications, movies and amateur communications made it necessary to move amateur equipment to another location. A soundproof shack was built and no further interference was encountered. Operation was almost exclusively on the 20-meter band.

Due to excessive cutput-tube casualties, plate voltage was dropped to 1500 volts and the set was operated on 500 watts input power. This arrangement began in June and continued for the remainder of the wintering-over period. Communications were excellent. For the entire wintering period, total outage due to equipment failures was six weeks. The maximum at any one continuous period was two weeks. The majority of equipment outages were due to storm damage. Propagation was superior for amateur radio. Most radio blackouts did not affect amateur communications on the 20-meter band. Propagation conditions for amateur radio could not have been more desirable.

Wilkes

Amateur radio equipment, utilizing maximum legal power was used primarily for morale and secondarily for IGY conferences. It contributed immensely to morale of station personnel and was invaluable for voice conferences with scientific personnel in the U. S. At least once a month any area could be reached in the U. S. A very conservative estimate of total operating time in a 10-month period is 3,000 hours.

A Collins Model KWS-1 transmitter and Model 75A4 receiver comprised amateur radio station KC4USK. The station was installed in a soundproof cubicle in the communications building. Performance of equipment was superb. Only two component failures for each piece of equipment were recorded. During a 10-month period, 16 vacuum tubes were replaced. None of the tube failures were considered unusual or excessive for the number of hours of operation involved. Three 3TF4A VFO filament voltage regulator tubes were supplied and used in the first 3 months of operation, which is considered excessive. The Collins Company should be notified of this design weakness with a view to eliminating the need for the 3TF4A in the KWS-1. A 25-ohm resister was used to replace this tube with no apparent effect upon the stability of the equipment.

The rhombic antenna was designed for the 40-, 20- and 10-meter amateur bands. Performance of this antenna was excellent. It was beamed for the geographic center of the U. S. and coverage of the entire nation was possible.

Ellsworth

The amateur radio was installed after naval communications were completed. A section of Radio Central was allocated for the ham shack and operations began approximately 1 March 1957. The KWS-1 (1000-watt) transmitter and a Collins 74A4 receiver were mounted on a standard Navy communication desk. The transmitter was matched to the rhombic antenna by a current feed balun designed locally and built out of copper tubing for both the 20- and 15-meter amateur radio bands. A changeover relay was used so that a single antenna could be used for both receiver and transmitter. Prior to construction of the balun, antennas available for ham operations were a 35-foot whip and a 375-foot longwire.

Due to a lack of a ground, the operation of two transmitters (Navy and ham) at the same time often caused interference. A system of warning lights was installed to give the ham operator a five-minute warning if his transmitter was interfering with Navy traffic or if the antenna was needed. This system proved to be highly successful. After the balun's were constructed so the KWS-1 could be used with the rhombic antenna, signals to the States greatly improved. Hamgram traffic increased and the number and quality of phone patches increased. Phone patches averaged about one or two every two weeks per man.

RADIO EQUIPMENT

Transmitters

TBM-10

The TBM-10 at McMurdo had been reconditioned by Mare Island Naval Shipyard. Most interlock switches had been reinstalled improperly, making operation impossible; several connections in the modulator units and the transmitter were not installed; and some of the keying relay contacts were welded together. The remote-control unit was designed for shipboard 4/6 wire control circuits and would have required almost 100 percent modification to adapt it to this installation. No provisions were made for a dc voltage source necessary to actuate remote relay/VT keying through landline control units. The antenna coupling unit was for the TDH series transmitters, and did not lend itself readily to this installation. It allowed loading of only one side of transmission line in spite of all the combinations of connecting that were tried. Two men installed most of the equipment in about 300 man-hours.

The TBM-10 at Little America was used constantly. With the use of a rhombic, communications were maintained with Radio Balboa and Radio Washington throughout February 1956 to January 1957. In spite of excessive use, this piece of equipment suffered only one major casualty.

That was a transformer in the rectifier unit. Effectiveness on omni-directional weather broadcasts was unsatisfactory. Directional transmitting antennas were employed expeditiously to produce the maximum coverage possible where the antarctic stations were located. Keying relay and blower motors required considerable attention.

The TBM-10 shipped to the Ellsworth Station suffered from rough handling. Most of the tubes were broken, part of the frame was warped, and the coupling for the inductance coil was broken. Otherwise the TBM was in perfect operating condition.

TBL-10

At Little America V this 250-watt CW/VFO transmitter was operated on high and low frequencies. The power was grossly inadequate for weather broadcasts, but this employment was not originally intended. It was received with only partially completed conversion between 4- and 6-wire control, and was incorrectly wired at Puget Sound where it was reconditioned. The side plates had not been securely fastened prior to packing, resulting in sheared bolts. It used a power supply from the TAB transmitter to produce 1400-watts power for the broadcast driving 4-1000 final. This modification was highly successful in additional broadcast coverages. It used a North/South doublet.

A TBL-10 served as the primary transmitter at Hallett Station. It proved adequate so far as power requirements, efficiency, etc., are concerned. However, due to non-receipt of the modulator unit, it was necessary to jury-rig a 20-watt phono amplifier to serve as a modulator. Modulation quality was excellent with this arrangement; however, the quantity could not exceed 50 percent resulting in low-power voice emissions.

Similarly, Wilkes Station received two TBL-10s without modulators. A substitute modulator was improvised from a commercial PA system amplifier. CW power was barely adequate for the Antarctic CW Common circuit and voice power was inadequate for continental communications. Faulty packaging of the equipment resulted in breakage of the glass mercury contact sections of relays in the landline control units.

The TBL-10 received at Ellsworth was in good condition. It worked satisfactorily after external wiring was completed.

TBW-4

The Byrd Station employed the TBW-4 as a secondary transmitter. It received only limited use, mostly on the low frequency side due to a complete lack of spares. The major trouble was the pick-up tap of the antenna RF tuning coil. As no spare was available, a new tap was cut from a tin can. Although workable, the efficiency of the transmitter was considered poor.

TBW-4s were also used at the South Pole Station. During the construction of the base, the TBWs were the only transmitters and they performed very well as high-frequency transmitters. Upon completion of the permanent station, the TBWs became secondary units. They were used as low-frequency homer beacons for aircraft and were poor to unsatisfactory. The maximum range an aircraft could receive the 125 watts from the transmitter was a mere 40 miles for the Air Force C-124 Globemasters; the Navy P2V-7 Neptunes could be landed on the airstrip and still not be able to hear the low-frequency homer.

At the Cape Hallett Station, the TBW-4 was initially used as the primary communications equipment. With the completion of the permanent base it was kept in standby for a means of emergency communications. This equipment proved adequate when used with a gas engine generator set. However, the noise level produced in the RBM-5 receivers by the 800-cycle generator caused great difficulty in receiving all but very strong signals. It became necessary to shut down TBW while receiving the weaker signals to reduce noise to an acceptable level.

TBA-10

The unit arrived at McMurdo in the original container with no apparent damage in transit. It had been reconditioned and stored at Mechanicsburg, Pa., prior to procurement by task force. Upon installation, numerous discrepancies were noted. No spare parts or instruction books had been shipped. The sliding contacts on two coils were corroded and burned, not making continuous contact. Two contact brushes were not properly reinstalled, making contact impossible. Contact roller pairs, not tracking on the same loop of coils, shorted the sections of coils. Control-shaft coupling sleeves between L116 and 118, L113 and 115, and C128 and 129 were secured in such a way that complimentary components in the same circuit were out of synchronization, decreasing normal range of variation and making balance impossible. Keying relay contacts were welded together. Due to an operational deadline, and the absence of an interconnecting wiring diagram, all interlocks were bypassed and the landline control unit was not installed.

The antenna coupler unit was inoperable. Switches had broken connections and contacts did not make. Coils had taps broken loose due to poor solder work. Sliding contacts did not make contact and several sections of rotor plates were shorted to stators. The rectifier unit was new and no trouble was encountered. A spare rectifier unit was inoperative due to heavy damage incurred during off-loading. Power transfer switch panel and magnetic controller, units normally used with M/G set powered equipment, were also supplied. No source of dc voltage was included for keying control. Two men installed most of the equipment in 168 man-hours.

During the time the TBA-10 was installed in the receiver building, it was down four to five times a week. The main reason was that static electricity generated in the antennas by high winds and blowing snow discharged across the plates of a capacitor in the final section, providing a path for high voltage to discharge across the plates, which caused considerable damage by arcing. The solution was to connect two one-megohm wire-wound resistors (25-watt) to both sides of the transmission lines and to a ground located close to the transmitter. The results were satisfactory with a three-quarter load on the transmitter and a high wind on the antenna. This trouble was not encountered when the equipment was moved to the transmitter building.

TAB-6

The transmitter shipped to McMurdo was apparently new and the rectifier unit definitely new. Both arrived in excellent condition. Landline control unit keying voltage was obtained from a DC source manufactured for use with the TBM-10. Forty-eight man-hours were expended in the installation.

At Little America this transmitter had a lack of range. Many tests were conducted with various ships and stations, with negative results. All indications showed that the transmitter was operating satisfactorily. The maximum range with any definite degree of reliability was 150 miles. Most of these tests were made with aircraft. On occasions, Radio McMurdo did hear the signals. The antenna was lengthened from 185 to 700 feet with no apparent increase in signal strength. A counterpoise was added but results were the same. Heavy interference (key clicks) was evident in all receivers. Except for occasional uses as an aircraft homer, this unit remained in stand-by status.

30K5

At Little America this transmitter was in constant use. Its performance was satisfactory but severely limited by crystal shortage until VFO was constructed on one channel. The changing of crystal frequencies was laborious. Two straight-wire antennas were used. Difficulty developed with the power amplifier tube when voice was used. Severe arcing caused gas to fill the tube. This same condition existed immediately after changing tubes. The corrective measure taken was to use the gear on reduced power. Difficulties were encountered also when using this set on CW. When plate voltage was applied, a loud hum would be heard on frequency. The receiver volume control had to be turned practically all the way down. No corrective action could be found to eliminate this condition. The only alternative was to use this transmitter on duplex CW circuit.

The 30K5 crystal-controlled, 300-watt transmitters were the primary transmitters at the Byrd Station. The 30K5 was considered a very poor choice; for such equipment at remote stations such as Byrd, the primary requirement is versatility. The 30K5 falls far short of minimum requirements because of the dependence upon crystals and the excessive time required to change channel frequencies. The RF antenna tuning coils on both transmitters changed inductance in a period of about 10 days, making it necessary to adjust the variable taps with a grid dip meter. Overheating of the PA plates on both 30K5s was a common occurance, making it necessary to detune transmitters.

The South Pole Station used two 30K5s as primary transmitters. They were very good to maintain communications as to the requirement for power. However, the versatility was inadequate. This and frequent failures of relays with limited spare parts available were not desirable qualities.

431-D

This 1-kw CW and voice high-frequency transmitter was installed at Little America. It had ten channels, crystal-control and auto-tune. The equipment was packed and shipped excellently. It lacked a VFO or FSK unit. Bypass by use of an LM frequency meter and a KY-58 keyer on the tenth channel permitted RATT and facsimile operation. This equipment was originally intended for airops use until Kiel Field built its own air/ground transmitter. Auto-tune was not wired because of lack of wire (not an operational inconvenience, though, because snow and ice effects on antenna required checking transmitter tuning on each frequency change). This was a very useful transmitter in all applications. It was employed throughout the antarctic continent (voice and CW) to Balboa and Syracuse (radioteletype) and to Washington, D. C. (facsimile). It provided great flexibility to transmitter capabilities of the installation. No technical troubles were encountered except that the first filter capacitor in the high-voltage power supply failed twice and one binding auto-tune bearing developed. It employed an unterminated rhombic directed to Balboa.

AN/FRT-15A

During the first tests immediately after installation at McMurdo it was discovered that RF oscillator O-140A/FRT-15 was inoperative. The trouble was finally isolated to the interstage transformer Z-3603 in the filter mixer F-104A/FRT-15, a sub unit of the RF oscillator. Close inspection of the defective transformer revealed that one lead had never been connected. The only other trouble encountered was in the power amplifier grid circuit. The resistive network of R-3952, 3953, and 3954 (all 4.7-k, 2-w resistors) decreased in value until an increase in grid current burned out one of the resistors. The fact that this trouble occurred twice may be because the resistors were underrated in the voltage rating.

AN/FRT-17

One of the troubles encountered at McMurdo was in the harmonic suppressor in the power amplifier plate circuit. Visual inspection showed that arcing had occurred between some of the turns of the coil L-505, eventually burning out the coil. It was subsequently learned that this same trouble had occurred at Little America Station and also aboard the USS Glacier. It is believed that this is a trouble in design and in that the turns of the coil L-505 are spaced too close. The only other major trouble encountered was in the blowing out of the line filter Z-801. This station has been prone to frequent power line surges and it is believed that this was the contributing factor to this trouble.

This equipment was received at Little America in a broken box, without an inner seal and full of snow, without tubes, instruction books, spares or crystals. It was received with the transmission coupling assembly incorrectly wired and without static drain resistors. The harmonic suppressor coil burned out as a result of mechanical failures of couplings on the tuning shafts; replacements fabricated locally failed. The transmitter operated without a harmonic suppressor. When the master oscillator needed replacement, and there were no spares at Little America, the locally contrived VFO/FSK used by the 431-D transmitter was employed, thereby limiting the effectiveness of the 431-D. The lack of crystals for the AN/FRT-17 therefore aggravated the lack of crystals for the 431-D. Performance, outside of technical difficulties which would not have been important if spares had been available, was good with Balboa and McMurdo. Used McMurdo doublet and optional longwire.

AN/FRT-24

At McMurdo, the only major failure in this equipment was that the power amplifier filament bypass capacitor C-130 shorted out. All other troubles were of a routine nature - tube failures.

Receivers

51J4 (Collins)

At Little America a Collins 51J4 was used very effectively but frequent burning out of the antenna circuit resulted because of local RF. This receiver was also used as a frequency meter. Dial calibrations were very accurate.

The 51J4s operated very well at the Byrd Station, with a minimum of trouble throughout the year. Corrective maintenance consisted of realignment and of replacement of neon static trap bulbs.

Three 51J4 receivers provided the South Pole Station with excellent reliability for Navy Communications as well as World Series, "Sputnick I" and other varied communications uses.

At the Cape Hallett Station, the 51J4 receivers proved superior to all other receiving equipment in every respect. Calibrated weekly with WWV, this equipment served as a frequency standard for setting up transmitters and frequency measuring purposes. Calibration, stability sensitivity, selectivity and fidelity of these receivers rated excellent.

Three 51J4 HF receivers comprised the primary receiving installation at Wilkes Station. This excellent equipment cannot be recommended too highly. The Navy should investigate this equipment for service use.

Primary reception was provided Ellsworth Station by three 51J4 receivers. Different combinations of receiving antennas were available and could be connected to any of the three receivers. The 51J4 gave very good reception on all bands, signal to noise ratio was good, and the 100-kc calibration check points were very well liked by both radiomen at this station. The power supply being part of the receiver made installing this unit very easy and fast.

RBA-RBB-RBC-RBM-RBS

This standard series of Navy receivers was used at all stations. McMurdo received two RBAs, four RBBs, two RBCs and one RBS, all in good condition and requiring a minimum checkout before using. Similar to the case of the transmitters, precipitation static was present in the receivers. As no insulated antenna wire was available, 100 thousand-ohm resistors were placed across the input terminals of the antenna and the results were satisfactory. Maximum efficiency was obtained from the RBA, RBB, and RBC receivers used at Little America.

RBM-5 receivers were used at the Byrd, South Pole and Cape Hallett stations. At Byrd and the South Pole the receivers were used as standby or secondary units and no trouble was experienced. However, at Cape Hallett the RBM receivers were unusable due to an overwhelming noise level from the 800-cycle power source for the TBW transmitter.

One RBA-7 was used at Wilkes Station. It performed satisfactorily and had no outages. The RBA at Ellsworth Station was used for low-frequency reception, using a 35-foot whip antenna. It was set on 500 kc for speaker watch on the distress frequency. Very little was heard on LF or VLF.

Transceivers

AN/GRC-9 transmitter/receivers were used at the South Pole in the weasel and in the Aurora tower as ground-to-air and ground-to-ground equipment. This equipment is quite reliable and performs very well under very rugged usage. AN/PRC-17's were supplied by the Air Force and were a backup for the ARC-1. The AN/PRC-17 is uncomfortable to operate in cold weather for any period of time due to its push-button controls. During summer operations and airdrops, an ARC-1 transceiver was used for drop-control (ground-to-air) circuits (121.5 mcs). This was very advantageous as it kept the primary antarctic air-to-ground circuit free of the drop-control traffic. About the only complaint in this system was the power supply to run the ARC-1. Frequent failure of the putt-putt necessitated shifting control to the antarctic air-to-ground circuit. A TCS-type transmitter/receiver was installed in the new weasel. This has more power than the AN/GRC-9. A voice contact was made with Byrd Station 600 miles away.

The AN/GRC-9 portable transceiver set proved to be superior in many ways to all other primary equipment at the Hallett Station. It was the most faithful and reliable piece of communications equipment. For the period during which the TBW was being permanently installed, the AN/GRC-9 was utilized with 100-percent efficiency for handling all traffic on the Antarctic Common circuit. During the 1957-1958 summer season, the AN/GRC-9 was employed on Air/Ground primary. Voice contact was maintained with McMurdo Sound, Little America, and with aircraft enroute between McMurdo and New Zealand. During the winter, all antarctic stations were worked CW at one time or another. The AN/GRC-9 proved to be a highly rugged, versatile, and reliable means of communications in nearly every phase of communications at Cape Hallett.

An AN/GRC-9 installed in a weasel was used for communication between Wilkes Station and the Ice Cap Station, a distance of about 50 miles. Communication was only fair to poor, and many schedules were missed due to inability to start the weasel in the extreme cold. In an effort to improve communications, a motor generator was fabricated using a 1-1/2-hp electric motor driving a weasel electric generator. The motor-generator was placed in the connecting tunnel. An AN/GRC-9 was mounted inside station living quarters. A four-wavelength sloping Vee antenna, oriented toward the main base, was installed, using the Met. mast for the high end. This arrangement made the radio more convenient to operate and insured meeting all schedules. This installation, however, suffered from a very high radio noise level due to sparking of the generator, which for all practical purposes nullified any advantages obtained by the use of the larger Vee antenna. Communication reliability remained fair to good. Possibly the installation of the slightly more powerful Navy Model TCS radio equipment would improve communications, although indications were that the station was sited in a skip zone and only application of "brute" power would insure reliable communications.

An AN/GRC-9 transmitter/receiver unit was installed in Ellsworth Radio Central for local communication and for contact with traverse parties while within its range (approximately 100 miles).

One AN/PRC-6 VHF transceiver was semi-permanently installed in the Wilkes Station Communications Building for local communications. In conjunction with a special antenna, this equipment performed excellently. Outages were attributed to battery failure. Due to cold weather, units in the field lost contact from inability to keep the dry batteries warm. When the batteries were kept warm, the field units had little difficulty in maintaining communications up to 13 miles from the main base. Antenna polarization of units in the field was very critical; to maintain reliable communications it was necessary to go to as high ground as practical and/or to move the boat to open water away from bays and inlets. It is recommended that arctic-type batteries be procured for future cold-weather operations. Procurement of the H-33/PT handset and AT-249/GRD RDF antenna would greatly improve the versatility of this equipment.

Teletype

Two Model 19's and two Model 28's were used at McMurdo. Their condition upon arrival was good. Installation and hook-up required 96 man-hours because of the need to manufacure a switching panel, as none was delivered with the equipment. Teletype maintainence was a continuing thing and required constant attention as the teletype equipment was the mainstay of communications. The greatest problem was with volcanic ash and dust getting into the machine and causing moving parts to wear beyond their normal rate. This was especially true of main shafts.

At Little America, radio teletype reception was good. Balboa signals were copied with little difficulty. Excellent reception was maintained when Radio Balboa used a 50-kw transmitter. Balboa-McMurdo RATT circuit monitored with excellent results to screen traffic for Little America. This system eliminated a CW relay from McMurdo. RATT transmissions by Little America were not particularly successful. After much difficulty and severe delay, RATT traffic was passed to Balboa on only two occasions. Even a TBM on high frequency, with a rhombic antenna, was unable to push a strong enough signal for good RATT communications. Various commerical press (RATT) were copied when conditions permitted. Excellent RATT press copies were received from various New York stations, which permitted printing of a daily camp newspaper. Many attempts were made to copy Australian RATT weather schedules, but the signals were very weak and a schedule was received only once.

Facsimile

Two TXC's arrived at McMurdo in good condition and required 24 man-hours to install, including construction of a table. Because of erratic operation of the keyer unit, few tests were made on photo transmissions from Little America.

Antennas

McMurdo

Two rhombic transmitting antennas were erected using four 45-inch pine poles each and guyed with five guys. Guy anchor rods were placed in holes that had to be drilled 6 feet deep with pneumatic drills. Forty-five-pound shape charges, two per hole, were used to make 4-foot holes for poles. Guys were made of 3/8-inch stranded cable, with break insulators. One quad receiving antenna network was erected around the communication building using four 45-foot pine poles each using three guys. They were erected in the same way as the rhombics. Three 25-foot pine poles were used for transmission line supports, each using three guys. A D8 tractor with boom was used to erect the poles. Much time was lost due to failure of the air compressor, to freezing of drill rods in the ground, to moving equipment from pole to pole, etc. Under ideal conditions the antennas could have been put up in approximately 1500 man-hours, instead of the 6100 man-hours expended.

A new antenna farm was constructed during Deep Freeze II. It consisted of two rhombics, three doublets, a whip, and a longwire. One rhombic was for CAA Auckland, New Zealand; the other for Radio Balboa. One doublet was orientated in a north/south direction, one in an east/west direction and the third in the direction of the Palmer Peninsula.

The distances and initial great circle courses were calculated for the rhombics. The Balboa rhombic was laid out as a Class "A", and the New Zealand rhombic as a Class "B". This gave the overall length of the Balboa rhombic as 707.5 feet, each side being 375 feet; the overall length of the New Zealand rhombic as 661.3 feet with each side being 350 feet. As the prefabricated masts could be assembled most easily in increments of 25 feet, both rhombics were made 75 feet high.

Since the doublet was to be constructed on a tilt, the side poles of the rhombics were used for the high end of the doublets and a 16-foot pole, laid off at 90 degrees from the long center line of the rhombic, for the short end. The right side pole of the New Zealand rhombic was used for the north/south doublet, and the left and right side poles of the Balboa rhombic for the east and Palmer Peninsula doublets respectively.

The installation of the anchors was the most frustrating and exasperating phase of the antenna construction. The auger-type anchor provided with the mast kit could not be screwed into the frozen ground and had to be modified so that the anchor could slip into a hole drilled into the permafrost by a jack hammer and star drill. Progress was made; but the drill would stick very often. By using 100 pounds of air pressure the jack hammer received such a jolt that it would not stick.

The masts were assembled and then raised by the gin pole method, a weasel being used for the pulling power. Downhauls were left on each mast to facilitate the stringing of the antenna wire. Three-foot holes were blasted for the 16-foot doublet poles, and the poles were easily set in place. The doublets themselves were assembled and attached to the short pole. Number 6 soft copper wire was used for the doublets.

The longwire was erected from the anchors sunk in the transmitter building plateau to a large rock outcrop on Fortress Rock. Number 6 copperweld was used and a feed-in of Number 6 soft copper wire was run directly to it from the transmitter building, making the total length of the wire 1100 feet. The 35-foot whip was moved to the transmitter area and installed in Fortress Rock on a frame of 4 x 4's.

Two transmitting rhombics constructed in front of the receiver building during Deep Freeze I, one for New Zealand and the other for Balboa, were to be used for receiving antennas. However, they were soon snapped up and put to good use by the amateurs. The existing receiving antennas were not changed, except for lengthening the longwire to approximately 600 feet, as they were satisfactory. All the newly constructed antennas performed very well.

It was considered that the type of prefabricated masts which were supplied, although easily constructed, were not superior. It was felt that a more durable type of mast should have been used - perhaps one of aluminum or light angle iron.

Little America

Antenna Construction. A new antenna farm of 51 masts was constructed in Deep Freeze II. The location was restricted by prior installations: Micrometeorology, Geomagnetism, the ionosonde transmitter, the GMD dome, and Deep Freeze I communications. Three masts were 24 feet high, made up of three hexagonal sections. Twenty-eight 16-foot masts were of steel pipe, and nineteen masts were of 20-foot 6 x 6 timbers. One 75-foot hexagonal mast was erected for the IGY Ionosphere Dept. Some masts were used for two or three antennas to reduce the total number of masts required and to permit a more effective use of the limited supply of antenna wire. These masts proved very satisfactory as used. Crossarms proved to be a major difficulty in all the transmitting antennas and transmission line poles. Crossarms were fabricated from 1/8-inch steel crossarm braces, 2 x 4's, 4 x 4's, or combinations of these. The 4 x 4's were used wherever possible, as they were easier to work with and gave better results. The 2 x 4's could not be placed under much strain when pin insulators were bolted through them; the metal crossarms would take very little strain without bending.

Antennas and transmission lines were made of the following wire: #6 copperweld, #6 stranded copperweld and #10 copper. The receiving transmission lines were 52- and 75-ohm coax. The mismatch could not be avoided, as there was insufficient 75-ohm coax on hand to allow its exclusive use. The transmission lines for the transmitting doublets and the rhombic were #6 copperweld spaced 12 inches to form 600-ohm lines.

The antenna construction at Kiel Field included the following: One V-Beam, each leg 130 feet in length; one 130-foot longwire, and one 200-foot longwire. Eleven masts were used. One was made of three hexagonal sections; seven were made up of 6 x 6's; the other three were 2 x 6's, used as supports for the transmission lines. Each of these antennas was fed by a 600-ohm transmission line constructed of 6-inch spacers and #12 copper wire. Lack of insulators was one of the two major problems encountered on this construction. The other was lack of proper wire. The hard-drawn #12 copper wire was replaced in September 1957 by copperweld. This was found necessary, as the solid copper had been stretched by wind and low temperatures and had sagged appreciably.

Antenna Construction Evaluation. There were sufficient mast sections of various types to construct the necessary antennas. The best masts appear to be the 20-foot 6 x 6's (telephone poles are also excellent). The most desirable crossarms are 4 x 4's. They are easily bolted to any of the three types of masts and to power poles. They have sufficient strength to hold up under any required stress.

The hardware supply, which was very limited, was almost exhausted. Much of the hardware used came from Little America III. Construction would have been very difficult without this outside source. Much of the material used had to be fabricated locally. A sufficient quantity of insulators was never found for a proper job of construction. Almost every insulator found at Little America III and V, including the few guy wire insulators, was placed into service as antenna insulators. Very few were of the proper type. The major trouble, other than small supply, was danger of breakage. All insulators have to be handled with great care. Coax is difficult to handle when cold, as it is stiff and cracks easily. All coax used outside should be armored for strength.

Antenna Performance. Three 600-ohm transmitting and four 75-ohm receiving doublets were used at Little America. Two of the transmitting doublets were used on the Weather Broadcast with apparent success. The use of directional antennas on a supposedly omnidirectional broadcast was initiated to overcome the power limitations of the equipment. Frequencies and antennas were shifted during the year to obtain the maximum coverage. The third transmitting doublet was used for the RATT/CW point-to-point circuit with McMurdo, and was successful except during periods of ionospheric disturbance.

The receiving doublets were designed to obtain maximum frequency and direction coverage for the Weather Intercept frequencies and stations, and the point-to-point and Antarctic Common frequencies. Because of this there were compromises and they normally operated under less than optimum conditions. In spite of this they were, in general, the most successful of the receiving antennas in terms of signal-to-noise ratio.

Three rhombics, two for Navy communications and one for amateur radio, were used at Little America. The two Navy communication rhombics, one receiving and one transmitting, were pointed toward Balboa, C.Z., and Washington, D. C. The receiving rhombic was one of the better receiving antennas because of its distance from camp and the quantity of wire contained. The transmitting rhombic with the 1-kw 431-D transmitter was successfully used to contact all the U. S. bases on the continent and many foreign antarctic IGY stations. In addition, it was used successfully for radio teletype and facsimile transmissions to Balboa and the United States. The amateur rhombic was constructed with the same dimensions as the existing rhombics since these had been successfully used for ham communications in Deep Freeze I.

The eight longwires were used in a variety of applications. One was very successful, but noisy, on the third weather broadcast frequency directed east and west. The 1000-foot longwire transmitting antenna was changed to receiving McMurdo's low-frequency tests. It was truly an optimum antenna for this purpose since it was oriented broadside to McMurdo. The remaining longwires were used for receiving and provided a wide selection of characteristics which the radiomen used to full advantage during the year.

The six whips were all constructed in Deep Freeze I and were used with some success in special circumstances, although the other antennas produced generally superior results. The 35-foot whip was a very useful receiving antenna during Deep Freeze I. Its location on top of the message center precluded its use as a transmitting antenna in Deep Freeze II because of the proximity to the receivers. It is believed that vertical antennas have many advantages.

The location of the transmitter building at a greater distance from the message center, with the attendant location of the transmitting antennas farther away from the receiving antennas, would have produced a considerable improvement in the effectiveness of the installation.

Recommendations. 1. Whip antennas with sufficient cable for favorable location and with adequate and convenient antenna switching devices should be provided the four U. S. bases being retained in the antarctic in Deep Freeze IV, so that opportunities for mutual contact will be possible technically. The locations of the remaining bases suggest that successful contacts should be possible with omnidirectional installations.

2. All bases should be provided with a 75- to 100-watt high-frequency transmitter along the lines of the AN/GRC-9 (but not necessarily equipped for teletype or facsimile) or the single sideband KWM-1 (but with Navy frequency coverage) for the base control station. The mobile stations should be equipped with 20- to 100-watt crystal-controlled or highly stable VFO-controlled transmitters capable of withstanding vehicular vibrations and bumps.

3. Transmitter and antenna research should be conducted in the antarctic to improve short-range portable communications, both vehicular and man-carried, under the extreme climatic conditions which are prevalent.

4. Teletype equipment should be provided for the outlying stations.

5. Authority to transmit in Russian should be noted in future task force Comm Plans along with authority to transmit messages in Spanish and French, if granted. Continuation of these and the addition of more foreign contacts should be encouraged as a valuable contributer to international good will.

6. All future antarctic communications installations and augmentations, and all antenna field design should be conducted by BuShips.

Byrd

One 30-foot whip was a 4-inch aluminum pipe tapered to 2 inches. This whip antenna proved to be the best receiving antenna available at Byrd Station. Reception improved 30 percent with the erection of the tunnel system, using this as an extra ground plane. Best reports received from all stations worked were on this antenna.

The longwire was constructed of #6 copperweld wire, 620 yards long, laid out north and south. Approximately 610 yards of the antenna were beneath the snow at depths from 6 feet on the northern end to 2 feet on the southern end. The longwire proved inadequate for everything but LF homing, which was unreliable but the best on hand. Reception of broadcast band stations was obtained but not to any great extent. By burying, it was found that a minimum of snow static resulted.

The rhombic, located approximately 150 yards NE of the station, was built from #6 copperweld with an overall length of 776 feet. Due to lack of antenna poles and to extremely bad weather at the time of erection, the rhombic was laid directly on the snow, with 4 x 8 posts, 8 feet long, sunk to a depth of 4 feet. The antenna became completely buried in about 3 weeks. The results on the rhombic were more satisfactory but still erratic. This antenna was used exclusively with the KWS-1/75A4 ham set. Considerable reduction in snow static was noted after it became covered with snow.

The dipole was constructed of #10 antenna wire. It was 150 feet long and 50 feet high, with a 6-foot spacer on either end. A two-wire counterpoise of the same dimensions was erected 6 feet above the snow and became buried in the snow after about a month. The dipole proved second in reliability only to the whip in working Little America and McMurdo. On occasions, it was used for LF homing with dubious results. Best results were between 6 and 9 mcs.

The doublet, a 20-foot antenna on 20-foot poles, was center-fed and beamed to radiate due north. Use of the doublet was discontinued after the erection of the rhombic. Constructed for ham use, it was barely adequate on 14 mcs, and useless on 21 mcs.

Due to the lack of material, no further antennas were constructed, although there was need for at least one additional whip and another rhombic. The rhombic should be approximately 3 wavelengths per leg, cut to 8 or 9 mcs, and beamed on McMurdo. While a whip in most cases is adequate, it is believed a rhombic would prove more dependable. With the installation of required VHF and/or UHF equipment, associated antennas would also become necessary, and installation would be simple.

South Pole

The antenna installation was comparable to a shipboard installation, with receiving and transmitting antennas of the longwire type, with the exception of the ham rhombic which was beamed at the Mid-Western United States. Transmitting antennas consisted of two longwires, one orientated broadside to Little America. Two 35-foot whip or vertical antennas were used for reception, together with one horizontal longwire which was orientated broadside to McMurdo. The VHF antenna was mounted atop the aurora tower. The emergency radio antenna was a standard TBW kit antenna and was erected broadside to McMurdo. This also served as the low-frequency homer antenna. The longwire antennas were installed from the Aurora tower, one broadside to the drop zone and the other broadside to the line of flight for aircraft on a drop run.

Hallett

Several types of antennas were experimented with, including the following: a doublet, a Hettz longwire, a VeeBeam, and a 35-foot vertical whip. The station was located on bare ground, which consisted primarily of fine gravel and penguin guano. Ground conductivity tests disclosed that during warm summer months resistances measured as low as 600 ohms, whereas during the colder months resistances as high as 4 megohms were measured.

Since counterpoising each antenna proved impracticable, experiments were carried out with half-wave and full-wave longwire antennas, cut to resonate at the frequencies they were to operate at. For 8975.5 kcs Antarctic Common, a 55-foot half-wave and a 110-foot full-wave antenna was used. Due to the poor ground, the full-wave antenna proved the best for transmitting. It seemed to make little difference to receiving.

Because of strong interference from ionosonde, several antennas were tried with the primary purpose of reducing noise level. The 35-foot whip proved most satisfactory for rejecting this type of interference without undue loss of signal strength. For the most part, full-wave resonant antennas were used for transmitting and the whip or the 1000-foot longwire for receiving. The building foundation trusses were bonded together and grounded. This served as a counterpoise for the whip antennas. A VeeBeam antenna was erected for the amateur radio in lieu of rhombic on an experimental basis. This antenna proved entirely adequate, with a band broad enough to work both 20- and 15-meter bands without adjusting the matching stub. A 1000-foot longwire was erected for the purpose of low-frequency reception. Used for both transmitting and receiving, it proved excellent over a wide range of frequencies due to its great length.

All antennas were erected using a haul-down system to facilitate maintenance and to eliminate the necessity for climbing poles. All antennas remained without casualty for the entire wintering-over period. As a whole, the antenna systems were little more than adequate. This was due to the compromise between having aerology and communications in the same building. Antennas had to be carefully placed to prevent interference with radiosonde equipment. The only exception was the VeeBeam antenna, which proved excellent in every respect. This antenna was remote enough from other antennas to prevent interference between circuits.

<u>Wilkes</u>

From the standpoint of mechanical strength, the steel masts and wire rope used for construction of the rhombic antenna and the strongback antenna system were very successful. However, a portion of the rhombic system was on a snow field, and during the summer months sunshine on the timbers at the base of the masts melted snow away and caused the mast to be atop a pinnacle of ice. From a radio propagation standpoint, the use of continuous runs of wire-rope guys made the theoretical prediction of antenna beam patterns impossible.

The strongback antenna system consisted of four 50-foot poles in a 50-foot square. These were connected at the top by messenger cables attached to down-hauls. Three 50-foot antennas were installed on the north and south sides. These were inefficient and were converted to

standby status upon installation of other antennas. A characteristic of these antennas was that the one on the south side would accept and radiate more energy than those on the north side.

A three-wavelength (at 8975.5 kc) longwire antenna, installed in a WSW direction, functioned very efficiently on the Antarctic CW Common circuit as a receiving antenna only. A 3-1/2-wavelength (at 9001 kc) longwire antenna, installed in an ENE direction, was used as a transmit/receive antenna for communication with the Wilkes Icecap station 50 miles inland. A 2-1/2-wavelength (at 10,000 kc) longwire antenna, installed in an east-west direction, was used by scientific personnel for checking chronometers with the National Bureau of Standards station. An 8-wavelength (at 8975.5 kc) Vee antenna was beamed for McMurdo and performed very well on the Antarctic CW Common circuit.

A small number of VHF and UHF antennas were installed to improve this type of communication. The MAY UHF discone antenna and the MAW-1 VHF equipment quarter-wave groundplane antennas were mounted at the ends of a 4-foot section of 1-inch pipe and then placed atop a strongback mast. The performance of the VHF antenna was good but the performance of the UHF antenna could not be checked due to lack of equipment. A 50-mc discone antenna was fabricated and mounted atop a strongback mast. This antenna was made to increase the operating range of the AN/PRC-6 handie-talkie radio set. The antenna succeeded in increasing the range from the design figure of 1 mile to 13 miles maximum. By picking an elevated or unobstructed location in which to use the set, trail parties could communicate with the base from any point in the Windmill Island Group.

A length of 3/8-inch copper tubing was laid on and then soldered to the communications building girders. All interior equipment was then connected to this common bus. Holes were then drilled through coarse to fine gravel into bedrock about 18 inches below. Ground rods were driven into these holes and soldered to the ground bus surrounding the building. The effectiveness of this "ground" is open to debate; however, the fact that all equipment was bonded to a common point helped minimize interference between equipments.

Ellsworth

Two rhombics, beamed on Washington, were erected by MCB-ONE summer personnel. Fifty-foot poles were used for both antennas and 20-foot poles for the transmission lines. The antennas which were constructed of #6 copperweld, 372 feet per leg, had a tilt angle of 72 degrees, and beamed 333 degrees true. The transmission line was #6 copperweld, with a total length of 1000 feet.

A longwire transmission antenna was constructed in early May when there were only a few hours of twilight left for outside work and the temperature was down to -40 F. The antenna was constructed of #6 copper wire, 375 feet in length, with the major lobes beamed in the general direction of McMurdo Sound. Two longwire receiving antennas running N-S and E-W, erected in early August, were constructed of #12 copperweld, approximately 150 feet in length. They were very good for reception but snow static was greatly increased on this type of antenna. Two vertical longwire receiving and transmitting antennas were erected. They were approximately 80 feet long, and were constructed of #6 copperweld. The slight difference in angle of these two antennas varied reception greatly.

Three whips, 35 feet high were spaced at intervals across the top of the building that housed Radio Central. Lead-ins were 52-ohm coaxial cable with the shielding stripped off. These leads were left extra long to allow any receiver to be hooked up. The bases of these antennas were very good for mounting on tops of buildings. Three guys of 1/8-inch wire were used to secure each antenna.

The feed-through insulators sent were designed for shipboard use, not for cold weather where the panels of the building were 4 inches thick. They were difficult to install and iced very badly. The stand-off insulators were too small to stand the strain of the wire which varied greatly with the changing temperature. The strain insulators were suited for the job. The different sizes (4 feet, 2 feet, and 1 foot) when used correctly supported all antennas during high winds with little breakage.

NAVIGATION AIDS

McMurdo

Navigation aids included the URN-5 Homer, the Racon, the TPS-1D Surveillance Radar, the MPS-4 Height-Finder Radar, CPN-6, and the Quad and Spar GCA. Most of these units were brought to an operational status prior to 17 October. However, flight checks could not be made. The Spar gear was never satisfactory. Cheap fabrication and construction caused frequent breakdowns in the cold and adverse weather. It was impossible to maintain both GCA sets in an operational status with but one electronics technician.

The URN-5, the CPN-6, the TPS-1D and the MPS-4 were located within the camp for proximity to a reliable power source. One of the major tubes went out in the MPS-4, the height-finding radar, before heavy flight operations commenced. Inadequate spare parts prevented restoration to an operational status. The low-frequency homer beacon (URN-5), the racon (CPN-6), and the surveillance radar (TPS-1D) had very limited ranges on certain bearings. Their location, surrounded on approximately

210 degrees by ridges and hills, precluded satisfactory reception unless the aircraft were at extremely high altitudes. On the other bearings, aircraft reported good reception of the Homer at 40 miles. Occasionally, the TPS-1D picked up aircraft at a distance of 80 miles. The usual procedure for aircraft approaching McMurdo further complicated the pickup of targets. Aircraft descended to an altitude of about 6000 feet some distance out.

The plans for Deep Freeze II and III called for the location of transmitters and an antenna field atop Fortress Rocks. Since this relocation would require a remote power source, it is strongly recommended that the URN-5 and Racon be placed atop one of the immediate adjacent peaks. Further, the surveillance radar, TPS-1D, should likewise be removed to a point where there is minimum interference.

The Quad radar worked exceptionally well, being troubled but occasionally with fluctuating current. There is, nevertheless, a definite need for an adequate standby unit in the event of power failure or undue fluctuation.

<u>Little America</u>

The electronics building at Kiel Field housed all navigational aids and aviation communications equipment. The Racon (CPN-6) was received in good order. However, none of the necessary test equipment or spares were received. Only one positive check of its operation was made and that was by an Air Force plane over Beardmore in November. All other tests were negative. Installation of the TPS-1D was begun in July. The main problem during installation was that of providing the large amount of power necessary for starting the 400-cycle frequency converter. It was subsequently found that by turning off all other equipment and having the two generators perfectly paralleled, the converter would start without kicking out the overload switch on the generators. The radar performed very well, with the maximum range target being an R4D at 5000 feet, 93 miles distant. Average targets were 60 to 80 miles distant.

No crystals were received with the URN-5 equipment and consequently the frequency was not that assigned. Using a 5kw generator, signals were readable to 75 miles and had strength enough for homing at 50 miles. This was not as much range as it was believed the equipment was capable of obtaining. The homer was moved from the strip to the electronics building to obtain greater antenna height. The metal in the building also provided a better counterpoise and simplified operation. In the new location, one report received from an Air Force plane over Beardmore revealed the signal had sufficient strength for homing at 475 miles. Average readability, however, was only about 50 miles. Later, the homer was moved 400 feet northwest of the buildings and a counterpoise field of chicken wire and copper wire was laid out around the homer. This had not been tested at the time of our departure.

A VHF Visual Direction Finder (URD-2A) was temporarily installed alongside the radio beacon shelter at the start of SAR operations in January 1956. Installation and alignment was fast and easy. Operation appeared very good. The maximum range experienced with this equipment was 60 miles; however, it was seldom used due to our radar capabilities.

The Spar (GCA) pedestal unit was damaged in shipment. The unit was a headache from the very first. The units were not wired according to the wiring diagrams. Some of the wiring diagrams were completely wrong and the equipment couldn't possibly work according to the diagrams. A tremendous amount of time was wasted on this equipment, as it never worked.

A temporary installation of the Quad GCA was made in February 1956 for SAR operations with the pedestal assembly and generator mounted on a large sled with the indicator group enclosed in a 10-man arctic tent. As a whole, this equipment was excellent in all four phases of operation (search, height-finding, precision, and ground control) and was invaluable during the summer air operations.

It was found that a magnetron was burned out in the CPN-6 and no replacement was available. By modification of the transmitter section the unit was made operational. Later range results of the equipment were given as 155 miles.

All navigational aids proved highly satisfactory with the exception of the Spar Radar. The Quad Radar MK III was very well adapted to the antarctic environment and it is believed that discrepancies encountered were not peculiar to climatic conditions. The Quad operated well at temperatures as low as -50 F and during winds as high as 38 miles per hour. During periods of non-use, keeping the antenna in the surveillance position permitted the azimuth antenna to weather-cock. The highest winds experienced for the year were 80 miles per hour. Those had little or no effect on the installation. The most noticeable effect of the low temperatures was that they required a considerably longer warm-up period to obtain stable operation

Byrd

No GCA facilities were available at Byrd Station. Aids to navigation consisted solely of one 125-watt, TBW-4 low-frequency homing beacon, and fuel drums placed to form a pattern for radar echo on the runway approach. The best distance was 140 miles, though the usual result was 30 miles, and in many cases the homer was not picked up until the plane was overhead. The much-needed DAU-4 RDF scheduled for Byrd Station did not arrive. In several cases, the C-124's could not find the station, although radio contact (HF) was excellent at the time. The A/G primary was also used as drop-control frequency, but was often unsatisfactory due to crowded conditions.

Hallett

No GCA or other landing system was available at Hallett Station. However, a URN-5 homer and a DAQ direction finder were available. The homing beacon operated with a high degree of success, with a 200-foot balanced "T" antenna without counterpoise. Range reports from aircraft varied from 50 to 350 miles. From the majority of reports received it would appear that the probable reliable range is approximately 200 miles. Fluctuations in station line voltage caused detuning of the transmitter. This made it necessary to use a gasoline generator as a power source for the beacon.

The direction finder was completely worthless and served only to take up space in the communications shack. It was received minus target transmitter and instruction book. The instruction book was received from McMurdo, but calibration of the DAQ was little short of impossible. Due to high winds in this area, it was impossible to keep the direction finder antenna intact. The counterpoise rods were broken off several times. It would be necessary to enclose this antenna in fiberglas housing to prevent storm damage. All tests made with the DAQ proved the equipment to be inaccurate and unreliable.

Wilkes

One Navy model DAQ Radio Direction Finder was installed about 200 feet from existing structures. Installation was difficult and calibration impractical due to lack of instruction book, calibration instructions and the calibration transmitter, and to inadequate personnel during the first year. Deep Freeze III should be able to make limited calibration using a vehicular radio installation. The equipment operated normally and had no outages.

Ellsworth

A low-frequency homer beacon (URN-5, 500-watt) was installed and tested. Good signal reports were received from Halley Bay (300 miles), and Port Stanley (approximately 1000 miles). The aircraft had trouble picking the signals up until the plane was within 30 to 50 miles of the station. A secondary homer, utilizing the TBL (250-watt) and spare keyer, was rigged in Radio Central for emergency and back-up operations. The TBL homer was used only when necessary, even though the pick-up range was greater than that of the primary homer. This was due to its location next to meteorology recorders, which failed to operate properly when the TBL was keyed on the low frequency used for homing operations. The different antennas available for hook-up to the TBL (rhombic, longwire, whip) are believed to give it a greater pick-up range over the URN-5, which had only an inverted "L" low-angle radiator.

INTERCOMMUNICATION SYSTEMS

Little America

The public address system was a talk-back type. The master control panel, which had a maximum capacity of 28 speakers, consisted of an amplifier and selector switches for each individual speaker, a monitoring and answering switch, and an all-call switch. Speakers were located in all buildings and three speakers were located in the main tunnel. No operational difficulties were experienced with this system.

Wilkes

Eleven Talk-A-Phone "Chief" Redi-Power Master units comprised the base intercommunication system. Packaging of this equipment was very poor and four units were received with damaged cases. In ten months of operation five were deadlined due to lack of spare parts and vacuum tubes. Four outages were caused by power supply voltage-doubling capacitors open-circuiting. Two of these failures were discovered upon installation. The manufacturer failed to supply servicing information or wiring diagrams which made servicing of the equipment difficult and time-consuming. This type of equipment was considered completely unsatisfactory in service.

PHOTOGRAPHY

McMurdo

Personnel

One photographic officer and three enlisted men wintered at McMurdo, which was considered adequate for the winter season, Deep Freeze I. With the beginning of the summer season, Deep Freeze II, the return of one man to CONUS due to injuries, the deployment of one man to Beardmore and one man to the South Pole Station, it became apparent that the number of photographic personnel assigned for the summer was inadequate. It was not possible to cover the many phases of activity necessary for complete documentation, and in addition to provide photographic support for other units and commands based aboard during the summer season. The naval squadron assigned was permitted to deploy only three photo mates and the photographic officer to the antarctic due to housing limitations.

One VX-6 and one MCB Special rated photographer were assigned to McMurdo for the wintering-over period of Deep Freeze II. This number was adequate for the winter period but both should have been battalion personnel. The additional personnel requirements of summer operations should be supplied by the unit with the photographic commitment.

Environment

Personnel engaged in photography did not consider the temperatures encountered prohibitive to photography. The clothing issued was adequate for warmth. Wet snow was the only detriment to photography. If photographers wear two pairs of contact gloves and large A-1-type mittens, their hands remain warm enough to load a camera after removing the A-1 mittens. Contact gloves must be worn at all times while loading motion picture cameras.

Facilities

The photographic facility at McMurdo Sound was housed in a 20-foot by 48-foot Deep Freeze-type building, which gave adequate space for operation and inside storage for some materials. Storage was primarily in a standard Quonset hut. All crated supplies, with weather seals unbroken, were stockpiled between these two buildings during Deep Freeze II. These stockpiles survived the winter with no loss or weather damage. Some mechanical equipment and copy cameras were excavated from under the surface after being out in the weather for a period of approximately 18 months and were found to be in perfect condition.

Water was the main problem encountered. Incoming water during Deep Freeze I was contaminated with sediment. Tanks and washers became further contaminated by the formation of algae. The water supplied during Deep Freeze II was clean except for an algae that formed a scum in the lab equipment and caused a surface scum on some films. Color film, having a soft, tri-layer emulsion, accumulated this algae much more readily than thin-emulsion black-and-white films. It was necessary to clean film wash-tanks and print washers constantly. However, it was impossible to clean the storage tank. Water filters must be used to help clean incoming water. Due to the location of the photo lab, waste water could not be drained as used but had to be accumulated in a waste tank. The water was pumped out of the building and allowed to follow natural drainage.

Electric power supplied to the photo lab was adequate, of a steady intensity, and very reliable. A laboratory temperature of approximately 70 degrees was maintained with no difficulty throughout the entire operation.

Film

All film supplied for Deep Freeze II was of the best quality. Minor faults found in the cold-weather operation of stock film were:

a. When using film packs, tabs must be pulled slowly, or the film will separate from the paper backing.

b. 120 and 35mm films get brittle, but care in handling and using will avoid difficulties.

c. The possibility of condensation of moisture on film is increased about 400 percent due to extreme differences in temperatures. Film must be removed from outside cold storage and brought to room temperature at least 24 hours in advance of being used.

d. Static marks were remarkable by their absence during operation. Many more were expected than appeared.

e. All roll films must be moved through the film transmission system of the camera in use, with slower speed and more care than is necessary in temperate climates.

It is recommended that the new RX-Pan film by Kodak be supplied in 120 and 35mm roll film sizes. Its speed (ASA 650) will expedite taking dim light, or existing light pictures of interiors that would be invaluable.

Cameras

Speed Graphics in use at McMurdo would not synchronize properly until the special lubricants used for winterization had been removed from the shutters by flushing with kerosene. Delubrication with kerosene was necessary at least monthly. Prior to de-winterization, the operation of the shutters was very erratic. All Graphics used at McMurdo operated well in temperatures down to Approximately -50 F when lubricated with a kerosene or xylene wash. At times shutters had to be warmed by body heat. On the whole, this was found to be the most reliable camera used. Solenoid synchronization was found to be impractical due to expansion and contraction at varied temperatures. Internal synchronization worked well, on both flash bulbs and electronic flash. No bellows failures were noted. Rubber connection cords were stiff and unwieldy at low temperatures but did not interfere in camera operation.

Graphic 22. Due to difficulty in loading at exterior temperatures and to the small size of exterior controls, this camera saw little use. At temperatures of -20 F, the sharp bends in the film transmission track caused film breakage. In bad weather (winds and snow) reflex focusing was impossible to use. Shutters in the Graphic 22 operated satisfactorily after de-winterization. The focus and film wind controls froze at -32 F. This could not be remedied locally as it was not possible to de-winterize the complete camera.

Graphic 35. It is not desirable to use the Graphic 35 at temperatures below -20 F it it is to be reloaded outdoors. When the film is cold, the threading end breaks because of the sharp bend on the take-up spool. Due to its negative size, it was used very little during Deep Freeze II. The exterior controls proved inoperative at -20 F.

Omega 120. This still camera was found to be excellent in temperatures as low as -30 F. Below that point the film transmission system, the automatic cocking of the shutter, and the shutter operation failed. Due to the size and location of batteries supplied for this camera, an exterior flash was rarely used. Coupled with electronic flash (with power supply under layers of clothing) this camera operated very well. It was used primarily as a secondary or "back-up" camera to the Speed Graphic. Overall results were very good.

Signet 35mm. Due to its negative size, this camera was used very little. Also, the exterior controls were inoperative at approximately -20 F.

Copy Camera 9X9, Modified for ASA Magazine. This camera was not used during Deep Freeze II, as the work load did not require any amount of reproduction, other than that which could be done on a smaller negative size. This camera was found to be in perfect condition after approximately 18 months storage under snow.

Cine Special. This 16mm motion picture camera proved to be excellent in cold weather, operating successfully in temperatures of -50 F. The camera bodies were kept at exterior temperatures, and only the magazines loaded at room temperature. This enabled the photographer to carry extra magazines, in case of film breakage, jamming, or magazine failure. At times the governor had to be set at 32 or 48 FPS to prevent the camera from slowing down due to extremes of temperatures. Only one Cine Special failed, and this was due to the focusing mirror falling, not the camera freezing. Lens controls, the winding handle, and other exterior adjustments were found to operate in cold weather. Internal heaters were found to be useless as it was impossible to maintain a source of electricity.

Bell and Howell Motion Picture Cameras. All 70KM's during Deep Freeze I were completely disassembled; the lubrication was removed, including graphite from the power spring, and the cameras were relubricated with kerosene. This permitted their use at temperatures of -50 F. It was not practical to use the built-in heating unit, as the power supply (Frezzolite) did not hold at these low temperatures. The motors supplied were very rarely used as they were noisy and ran hot. A quick-wind handled is very important for use when the spring wind is utilized due to the short film run of 23 feet. One camera had a governor failure. The Veeder counters were the source of considerable difficulty, as they were not properly secured to the camera body. This deficiency in design has been rectified in the later model which has a counter mounted on the bracket. All cameras had to have the aperatures cleaned after each roll of film as emulsion chips would gather rapidly because of the extreme cold temperature. This was best accomplished by the use of a good non-shedding paint brush. All cameras should also be thoroughly cleaned after each 1000 feet of film and a drop of kerosene placed in oil holes.

The B&H has very little practical use without a heater in extremely cold weather. The camera froze at 0 F. After relubrication with kerosene, the 200 ran efficiently at -35 F. As it is a magazine-type camera, the B&H 200M was not used extensively during Deep Freeze II. It was utilized as an emergency camera and several were kept at strategic places around the airstrip for use in case of regular camera failure. Changing lenses in cold weather is difficult and sometimes impractical.

Kodak K-100 Motion Picture Camera. The simplicity of the loading of this camera made it very desirable for use in cold weather. It operated successfully at -35 F, and the exterior controls were found to be easy to use, reliable, and well protected from ingress of snow or moisture. Care must be exercised in loading to form the correct loops. The open, free-flowing loops of the K-100 give the film an excellent chance to avoid crimping or breaking due to brittleness at low temperatures.

Cameraflex 16mm, Mitchell 16mm, Signal Corps 70mm. The Cameraflex was not used operationally, as film scratch was apparent in both magazines. The Mitchell was not used because of its weight. It is not recommended for hill country. The Signal Corps 70mm failed at relatively high temperatures (-0 F to -10 F). It is not recommended for cold-weather operations.

Accessories

Batteries. All dry-cell batteries were found to operate with maximum success if kept warm by body heat. All outside cameras were equipped with battery cases that could be carried next to the body. Exterior cases, such as on the Speed Graphic and Omega 210, were found to be impractical unless protected by body heat.

Wet-cell batteries met with little or no success. It was found impossible to maintain any charge in wet cells at any low temperature. The utilization of body heat proved inadequate.

Electronic Flash. An electronic flash was utilized for most outdoor illumination over the winter night. By keeping the power unit warm with body heat, a flash was obtainable at -55 F. The only failure was in the rubber cord covering, which became stiff and brittle at low temperatures. Breakage was held to a minimum by careful handling. During the total darkness it was found that as many as four flash tubes could be operated from twin-power supply units.

Film Holders. Film packs require extremely careful handling at low temperatures. Due to the tendency of film to tear or separate from paper backing, packs are not recommended at temperatures lower than -15 F. Cut-film holders were the most successful, due to simplicity of operation.

No failures were found. "Graphmatic"-type holders were found to be impractical; temperature changes caused the septums to expand and contract, scratching all films exposed in them. After some experimentation, this kind of film holder was not used.

Tripod Pro Jr. Because of its light weight, this is an extremely practical tripod for use in the antarctic. All special lubricants were removed from the tripod and it was relubricated with kerosene.

Motion Picture Slates. It is not considered feasible to slate all motion picture photography because it is impossible to write on a plastic surface with a grease pencil in low temperatures. Also, it is time-consuming.

Laboratory Equipment

The Temprite unit will not accommodate three processing tanks for 400-foot rolls. The N-9 unit was used, as it will accept three B-6 tanks. Temprite units were not needed because the building was maintained at the correct temperatures necessary for the storage of solutions and the processing of films and papers. The Oscar Fisher Heater Cooler Unit (HC-2) was not used at McMurdo because of the excessive amount of water required for operation. All other laboratory equipment such as washers, dryers, enlargers, contact printers, etc., operated with complete success. Papers, developers, and color developing kits presented no problems.

Film Processors. The motion picture automatic film processor manufactured by Photogrametry, Inc. was thoroughly tested during Deep Freeze I. A clear glass or plastic shield should be provided to cover the flourescent lamp housing. Liquids splashing on terminals caused an electrical short which lighted the lamps during processing and ruined the film by fogging. The 16mm loading unit was not practical as the first 30 feet of film loaded was unusable. Drying time is excessive. Water spots were apparent with and without the use of photo-flo. Reel drive gears in the processing well rusted badly and should be replaced by a non-corrosive metal.

The Model 55Q-10 film processor for 16mm, 35mm and 70mm film was not used at any time during Deep Freeze II. The water requirements for this process is large, and since all motion picture processing was accomplished at the Naval Photographic Center, Washington D. C., it is unnecessary equipment at McMurdo.

Chemicals

Pako Gloss and similar glossing solutions were found to be highly impractical due to algae in the water. All prints were dryed matte, or semi-matte, to eliminate this problem. Because of the very low relative

humidity at McMurdo, Photo-flo was not used as it caused drying marks rendering film unusable. Film dried at a very rapid rate (10 to 15 minutes). The lack of humidity caused films to dry with smooth, clear surfaces. Hypo eliminator is a must in any area where water is hard to get.

Recommendations

1. If a mission for aerial photography is assigned to the task force for Deep Freeze III, at least six men will be required for processing. These men are in addition to personnel who will normally be utilized for the administration of the photo lab, i.e. motion picture and still photography.

2. A team of motion picture photographers should be assigned to the task force to further document the operation. This will permit greater mobility and wider coverage. During the lull in operations at a given location, photographic personnel could be shifted by the staff photo officer. Personnel should be more thoroughly screened for personal ability.

3. It is recommended that all established bases having photographic installations submit replenishment requirements by message to the proper authority in order to prevent the procurement and shipment of photographic items not required. This should be done by 1 June each year.

Little America

Facilities

The facilities of the Photographic Laboratory at Little America were adequate for accomplishment of the assigned mission. Still and 16mm motion picture photography in both black and white and color were satisfactorily accomplished, including the processing of still color film. Facilities for motion picture processing did not exist. Sufficient equipment had been provided for the processing and printing of 380-foot by 9-1/2-inch aerial film.

The photo lab consisted of a darkroom and combination finishing room and office, utilizing one half of a building which is also the main head and laundry. Water was piped into a 300-gallon storage tank located in the building. The water at the cold tap outlet varied in temperature from 85 F to 110 F. Hot water (125 F) was always available for mixing chemicals.

Because of this situation, an Oscar Fisher cooling unit and a Powers mixing valve were installed. A constant temperature could be maintained in the range of 55 F to 130 F. Pressure was sacrificed with this

installation, allowing a minimum flow of about one gallon per minute at 55 F to a maximum of about four gallons per minute at 90 F. Sixty-eight-degree water could then be available for two hours without harmful effects to the cooling unit. The water used to cool the condensing coils of the unit was a justifiable waste and should be considered negligible in the final evaluation. Contaminated waste water from the sink and print washer was disposed of by drainage underneath the building.

The cooling unit went out of commission after about ten months use. While operational, this unit was not satisfactory due to insufficient water pressure. As an alternate, the re-circulation unit was hooked up and tap water was run through this device. By reducing the volume to a trickle, 68 F water could be obtained. The failure of water cooling systems seriously hampered the development of color film and much film was lost as a result of reticulation.

Environment

Dryness was a characteristic which was always present. Although the photo lab was in an ideal building with regard to humidity, it was much drier compared to most Stateside photo labs. Dust and lint from the clothes driers settled on negatives with almost magnetic force. Anti-static negative brushes were needed, as regular camel hair brushes did not repel but seemed to attract dust particles. Photographic prints, enlargements or otherwise, had a natural tendency to curl tightly, especially when dried glossy. In many instances the emulsion cracked when prints were straightened by hand. A few minutes in a wetting agent (Photo-flo solution) after the final wash prior to drying reduced this condition.

Storage

Two large lockers were used for storage of film and smaller items such as exposure meters, 35mm cameras, extra lenses, and the like. At least a 15-degree difference prevailed between lower and upper shelves. During the winter months a 30-degree differential was not unusual. Storage for bulkier items presented the greatest problem. It was non-existent during the initial construction period. Essential material for immediate and normal operational requirements to cover the winter period received priority for the limited space available inside the lab and above the darkroom. Some material such as aerial film, Sonne paper, processing kits, and chemicals were left in the outside supply dump.

Cameras

Speed Graphic. This camera proved to be the most versatile for inside as well as outside work. The internally synchronized shutter, winterized to -75 F, was the prime cause of trouble. At -15 F, flash synch

was very unreliable for Class N lamps. However, electronic flash and synch settings for Class F lamps functioned properly. Working under temperatures of -25 F for a period longer than one hour is useless because of the erratic shutter operation, not only in synch but also in speed. Cleaning the shutter in gasoline helped some. During Deep Freeze II, xylene was used to completely dry shutters. The shutters would then operate in prolonged temperatures of -50 F, and one shutter to -55 F. The range finder of the Speed Graphic is ineffective below -40 F. The internal synchronization does not function properly below -15 F. Dark slides from the plastic "Riteway" holders cannot be returned to holder when temperatures are below -50 F. The wooden holders performed satisfactorily at all times. The flash, shutter and extension cords provided during Deep Freeze II with the Speed Graphic cameras froze and the slightest bending broke or cracked the cable causing shorts and no contacts. The dry-cell flash gun was found satisfactory to -30 F. Below this temperature additional power from three wet silver cells wired in series was plugged to the battery outlet in the flash gun. This combination was not known to fail at any time, and worked in temperatures to -60 F.

<u>Super "D" Graflex</u>. While some excellent photography can be done and the camera can still be operated reasonably satisfactorily at -40 F, the Super "D" Graflex had one particular drawback for cold-weather operation. Accidental breathing on the focusing ground glass via the dark hood is disastrous. Moisture in the breath freezes on contact and cannot be cleaned outdoors. Taking the camera indoors puts it out of commission for at least an hour or longer due to condensation. All cameras must be thoroughly and completely dry before being used outside. Inside photography, under floodlight illumination, on many occasions required longer exposure than those calibrated on the Super "D" focal plane. Flash lamps were not available.

<u>Signal Corps 70mm Combat Camera</u>. This camera developed a malfunction the very first time it was tried. The focal plane shutter curtain jammed and broke. Hence no further evaluation was made. Shutters on the Combat Graphic were inoperative when received and were never used or tested.

<u>Cameraflex 16mm</u>. The Cameraflex required external power but did provide a means of viewing through the lens for precise focusing and composition. It did not prove too successful when using fast film because of the dull image reflected to the ground glass from the small aperture needed. The magazine, which was gear-driven and very unorthodox in loading, left too much chance for error. More than full capacity loads are possible but not very practical. Film was exposed in the Cameraflex at -40 F only as a test. In all respects the camera functioned properly except for the frames-per-second tachometer. An unusual amount of noise was produced from the film magazine but nothing else out of the ordinary was noted. The power cable became stiff and would have cracked

if motion picture techniques were used. One hundred feet of both color and black-and-white film traveled through the camera mechanism at 24 FPS at -40 F without a film break or jam. Some scratches on the film base were visible but could have been caused by improper handling during development; if not, more likely by the magazine film trap than by the pressure plate.

Simmons Omega 120. This aerial camera operated with better than expected results while exposed for over three hours at -62 F. The automatic film transport operation on both of these cameras became stiff but still worked. Flash synch was not used or tested under this condition. It did operate at -35 F, so it can be assumed that synchronization is satisfactory at -62 F. The Omega 120 was far superior to any other still camera. Of the three Omegas at Little America during Deep Freeze II, only one was known to fail; the shutter froze open after prolonged exposure to -55 F temperature and the internal synchronization would not function. This camera took the rough wear and the unusual conditions of the antarctic better than the other cameras.

F-56. Of the aerial cameras used, the F-56 worked best and ranked highest under varying conditions. It was an all-around work horse in the air. Of the three received during Deep Freeze I, one was not used because of a pitted lens, which caused an allover softness of the image. One F-56 camera was damaged during a flight when the temperature was -46 F. Shooting was done through an open door of the plane. Manual operation became quite difficult, so electrical power was used. Soon after the camera became inoperative. It was later determined that a taper pin in the case drive had sheared. This camera had been winterized to a temperature of -65 F, according to information on the tag.

K-20. Although the K-20 operated at low temperatures, the negative size was objectionable.

CA-328 (K-17B). This camera was installed in an Otter aircraft but never exposed any film, and was not evaluated.

Cine Special. The Cine Special was used almost entirely for motion picture photography at Little America. End tests were made from time to time to check for synchronization, focus and scratches. In a few instances the pressure plate moved out of alignment while traveling via weasel or D8 tractor over rough terrain. The magazine of the Cine Special is very awkward to thread in cold weather and cannot be loaded when attached to the camera. Loading the magazines outside in cold weather is possible but not advisable, especially when snow is blowing. Also, because of the somewhat difficult threading procedure, gloves must be removed for accurate loading. Contact gloves can be worn, but they too offer a certain amount of resistance. Accidental breathing into the open magazine chamber causes instant freezing, locking the take-up action or the pull-down claw movement.

All the winterized Cine Special cameras operated the same. Cameras winterized both to -35 F and -75 F did not function properly at -62 F but did operate from -50 F up to room temperature. During the winter, most motion picture photography consisted of inside coverage in which any of the cameras were satisfactory, but personal preference and results indicated the Cine Special. One Cine Special (over a year old and well-used) which was winterized would not operate at over 16 FPS after prolonged exposure to temperatures of -40 F. The lens diaphragms froze up and could not be moved after one-half hour in temperatures of -35 F. When warm the lens diaphragm floated entirely free and the slightest jar or rubbing against a coat sleeve would stop it down to 22. A lube-free click stop diaphragm is recommended. The new winterized (internal heaters and jacket) model sent down for Deep Freeze II was unsatisfactory. With the jacket on the camera and heavy clothing on the operator, one cannot get close enough to the magazine to see through the prismatic viewfinder. The cement in one of the prismatic viewfinders faded and caused a distorted image, making it useless.

Mitchell "16" Motion Picture Camera. This camera was shipped down during Deep Freeze I, but was never used until Deep Freeze II. According to the tag, it was winterized to -70 F. The camera was successfully used indoors. On the first occasion outdoors the micro-switches froze in an open position making it impossible to get power to the camera motor. It was extremely hard to rack over, the lenses were impossible to focus after a short period, and the f/stop ring could not be adjusted. The above occurred during temperatures of -38 F. The camera was stripped down, all grease was removed, and the micro-switches were locked in the closed position. The camera was then operated absolutely dry except for the cam which operates the registration and pull-down system. This particular Mitchell had excessive grease in it for operation even in normal climate.

K-100. The K-100 was one of the most useful cameras. It was comparatively easy to load in the cold, and would operate satisfactorily without the heaters to -35 F. With satisfactory battery power for the heaters, no trouble was encountered at even lower temperatures. On extended tours of this nature, additional pressure plates should be brought along, or a good metal one manufactured and incorporated into the camera. The chrome metal strip around the camera caused a number of face burns when cold. For short periods this camera operated at temperatures of -57 F. If this instrument were completely free of lubrication it would operate in most temperatures encountered.

Bell and Howell 70KM. These motion picture cameras operated successfully during the relatively warm summer months without the use of an electric motor or internal heaters. However, when the temperature dropped as little as two degrees below zero, trouble developed. The FPS speed slowed down to such an extent that 24 FPS could not be maintained after

one or two hours with an indicated governor-controlled speed of 64. If camera operation was prolonged under this condition, camera failure occurred; all movement seemed to freeze. Completely thawing the camera at intervals kept it in operation. Apparently, heaters are mandatory for below-zero filming with the 70KM. Heaters were not used because of the extra equipment needed for their operation and because the Cine Special was available. A 70KM, complete with electric motor, 400-foot magazine and cold-weather covers, was set up under temperatures of -20 F, but completely froze up after exposing only four feet of film.

Bell and Howell 70KRM. The 70KRM (a slight variation of the 70KM) was used only inside during the winter night, but was taken on the first tractor train. It performed well at all times. The internal heaters were not used at any time. The 10mm lens was used extensively while filming Little America interiors; the 10mm is also most effective for many exterior scenes.

Film

Super XX was the most needed and used still film. Slower emulsions required a larger opening and a loss in depth of field. Ansco Supreme film packs received from McMurdo had a very fine leatherlike pattern (a miniature reticulation) which covered the entire negative. There was no logical explanation unless it was due to storage conditions. ASA 200 (TRI-X) 4 x 5 sheet film was most important and many more exterior exposures could have made during the winter night if it had been available. Type "F", 120, interior color is a most useful film for flash color. A critical shortage of film seriously hampered the operations of the lab during the winter night. Work during most of the winter night was nearly all done on Portrait Pan Film, ASA 50.

It is believed that the film provided should have been more up-to-date. Color films (4x5) with a speed of 12 (daylight) were provided when there are films with a speed of 125 that could have been provided. The same holds true in black and white. In order to photograph winter night activities properly the high-speed films are needed. Some ASA 80 and ASA 100 should be provided for summer work, but in main the material should be the fastest film available.

Accessories

Film Packs. Film packs would not operate below -25 F. Below that temperature the film would tear, leaving the exposed sheet in front of the pack. Graphamatic holders were useless except during warm summer temperatures.

Batteries. Silver Cell batteries and the Jacket combination was not considered successful. The batteries were fine, although too many of them were required for the necessary voltage. The method of carrying the batteries was not suitable, because the wires would snap during extreme cold periods and consequently the circuit would be open.

Meters. Exposure meters, indident or reflected types, are subject to error under the light of the antarctic sun. Reflected-light meters pick up too much light from the sky and snow, giving an incorrect high reading and causing underexposure; incident meters do not record enough light, causing a slight overexposure. Generally speaking, the incident-type meter is more accurate. Trial-and-error tests indicated that the lens must be stopped down one-half f/stop from the calculations determined on the Norwood Director and opened up at least one and one-half stops from the Weston Master II computations. The basic overall exposure with speed group 100 film is 1/200 @ f/11 with K-2 filter. For daylight color film speed group 10 with skylight filter, the exposure is 1/50 @ f/9.

Chemicals

Microdol and D-76 were the commonly used developers. D-76 was used for aerial work and gave excellent results. Microdol, giving a slightly flatter image, is especially useful for exterior black-and-white still photography because of the high contrast obtained. Microdol is recommended for still work and D-76 for aerials.

Comments and Recommendations

Equipment. Motion picture photographers must travel as light as possible. More efficient motion pictures can be made if only the minimum essential equipment is used permitting free movement of sequence shooting.

Color temperature meters and filters were not used because of the loss in exposure (4X). When exposing daylight-type color film, a skylight 1A or UV-16 filter is recommended at all times for outside shooting. Slight corrections for improving quality and the protective factor to the lens make a filter mandatory. Likewise, black-and-white exposures should be made through A-2 or Aero-1 for best results.

Due to the brightness range between highlights and shadow, a fill-in is strongly recommended for still photography. Electronic flash has all the qualities needed, such as compactness and ease of operation for synchro-sun photography.

Cameras. Winterization of cameras was extremely poor, and in some cases completely ineffective. The only still camera which was nearly trouble-free was the Omega 120. Movie cameras varied, but all were troublesome to a degree in the cold.

The ideal movie camera is the German-made Aireflex, 16mm reflex, power-driven (8-volt) camera. This camera produces footage comparable to the Mitchell "16". The Mitchell was used by the Disney photographer without heaters in temperatures down to -70 F during Deep Freeze I. It was operated dry at all times and produced excellent, trouble-free results. The K-100 and the Mitchell "16" are considered the best cameras the Navy has for this type of operation.

Still cameras for work in the cold should be of the roll-film type. The 120 Omega was completely successful. The 35mm cameras should be investigated. The variety of lenses and films available for 35 would be an asset, as would the minimum bulk of the equipment. Photographs can be made with the modern 35 equipment and films which in many ways are superior to those made with any other type of camera. Night exterior photographs made on Tri-X with the Speed Graphic were shot wide open (f/4.7) at a quarter of a second. With the modern f/1.1 to f/1.4 lenses, photographs of this nature could be made which would stop action. Personnel assigned to use 35mm equipment should be thoroughly indoctrinated in its capabilities and limitations. Wide-angle lenses for the Speed Graphic were definitely needed for inside work.

Film Identification. Slating is an excellent means of identification, but under constant snow conditions it is an added burden. Cold weather does not allow china marking pencils to write on plastic plates. A simple way to identify film is to mark code and roll numbers on boxes corresponding to each exposed roll. Further identification by the processing department to keep rolls and boxes in correct order is always possible. Date sheets have all the pertinent information. Under the conditions, slating should not be expected.

Byrd

Official photographic coverage of Byrd Station took place only during the summer months by Navy photographers who came with the tractor train or were flown from Little America during periods of construction and air operations. These photographers took both moving and still pictures of all phases of summer operations at Byrd Station. The station darkroom, located in the head, was equipped with available materials. Commensurate with the needs of the scientific program, the darkroom was available to all personnel.

South Pole

Personnel

No photographic personnel were assigned. Coverage through the winter was handled by various Navy personnel and was basically unsatisfactory. Summer coverage was handled by Navy photographers from McMurdo. Responsibility for photography should be assigned to one individual prior to departure from the States. The person selected should have sufficient experience, training and interest to carry through an adequate program.

Equipment and Facilities

The darkroom was divided into two sections, one for scientific use and the other for recreational use. The latter contained adequate equipment and facilities for both recreational and naval photography. Photography was one of the most popular recreational activities. It is recommended that full supplies for this purpose be provided, including ample photo paper, color developing kits, etc.

Prior to the departure for the South Pole, two Bell and Howell 70KM 16mm motion picture cameras were completely disassembled, the winterization oil and grease removed, and the cameras relubricated with kerosene. All graphite was removed from the mainspring to permit operation of the cameras without the aid of heaters. With the mainspring lubricated with the graphite, the spring motor would start slowing down at -25 F. It is believed that this was caused by the graphite being contaminated by the winterization oil. All still cameras, including the shutter assemblies, were relubricated with kerosene. The Pro Jr tripod was treated in the same manner.

The "Graphlex 22" 120 roll-film camera froze up almost immediately upon removal from the aircraft. The shutter would release, but it was not possible to either focus the camera or wind the film through because of the temperature of -30 F.

During the forty-five day construction period at the South Pole Station, approximately 20,000 feet of color motion pictures were shot with cinemascope and regular 16mm film, plus many color and black-and-white still photographs. All cameras held up well during the entire period but required very frequent cleaning to remove the flaked particles of emulsion from the film gate. This was caused by the brittleness of the film at cold temperatures. A one-inch paint brush was used to clean the cameras after each roll was shot. Only 100-foot rolls of 16mm Kodachrome were used in the Bell and Howell 70KM cameras. Both of the 70KM cameras were operated by the use of the spring motor.

The cameras were never taken inside a building except for major cleaning or relubrication. If taken inside, the cameras immediately got wet inside and out because of condensation. It would then take three or four hours to get them dry enough to use outside without freezing up. Usually the cameras were left outside on the tripods when not in use and were covered with a dark cloth or bag to prevent blowing-snow crystals from covering the lenses and other vital parts. The only difficulties encountered with the equipment were with the Pro Jr tripod. The gear ratio of the tripod head should be about doubled and the clearance of the gear teeth be reduced to prevent too much play while making a pan shot. Slating each roll of motion picture film was almost impossible, as the grease pencil would not write on the plexiglass in extreme temperatures.

Hallett

No photographer was assigned to this station. However, one Omega 120 still camera and one Cine-Kodak K-100 movie camera were available. A darkroom was built in the recreation building. Water was supplied from a 980-gallon storage tank. During the wintering-over period, nearly 300 negatives were developed and 1400 feet of color movie film were taken.

Wilkes

The station photographic facilities were very good. The addition of an 8 x 10 copy camera would have been of considerable use for copy work and it would also have other technical applications. The 7 x 7 contact printer could print only one 4 x 5 negative at a time, whereas an 8 x 10 printer could have done four at once and saved printing time. A wide-angle lens for the Speed Graphic camera for use in photographing interiors would have allowed better coverage. Separate water filters should be provided for the darkroom water supply to keep it free of foreign particles.

Section IV

ADMINISTRATION AND PERSONNEL

GENERAL COMMENTS

Originally conceived as an operation which would entail little field administrative work, experience promptly contradicted this impression. Administration problems in Antarctica were the same as at any naval facility in the continental United States, with the additional difficulties of having to rely on messages in lieu of letters since mail service was nonexistent for nine months of the year. As the direct result of such lack of mail service, many notices and instructions of higher authority were soon outdated.

The main administration for Deep Freeze I and II was carried out at Little America Station for the entire battalion, and pay and service records were therefore held at Little America. Personnel at other bases were frequently transferred back to the United States on extremely short notice and their records would be at least 400 miles distant, with no means available for obtaining them. Obviously, such separation worked innumerable hardships on the personnel concerned.

Each main base should be treated as a normal installation, with its own set of up-to-date manuals, instructions and notices, and an adequate administrative staff. Inability to properly handle problems as they arise results in the direct deterioration of morale. Prompt attention and action on such problems has the opposite effect of making each individual feel that, even though he is at this isolated outpost, he is being afforded every opportunity that he might have had he remained within the normal boundaries of civilization.

If adequate records are to be submitted, daily recordings are necessary, and such details are considerably eased by having clerical personnel who either take shorthand or operate the stenotype machine.

All types of minor legal problems arise, and the counselling of personnel on many personal problems demands a rather comprehensive knowledge of naval administrative procedures as well as a sympathetic viewpoint. All appropriate forms should be brought in sufficient quantities; i.e., Annual Officer Qualification Questionaires, Officer Data Cards, Fitness Reports, Enlisted Personnel Evaluation Forms, Security Clearance Forms, etc.

With the influx of the augmenting summer groups, as in December 1956, hundreds of orders had to be endorsed and records picked up and maintained by MCB (Special) personnel, as such groups did not bring their own clerical personnel. McMurdo was Radio Central and Weather Central for the antarctic. As the commanding officer of MCB (Special) was located at Little America Station during Deep Freeze I, all traffic had to be passed along to him. Because of this, the administrative workload at McMurdo was quadrupled.

Disbursing presented few problems during Deep Freeze I. An agent cashier was at McMurdo Sound with the disbursing officer at Little America. It is not felt that comment on the newly-established credit system in the antarctic can be made at this time. A few problems arose during the summer season with regard to the credit system, but it is believed judgment should be withheld until enough time has elapsed to "work out the bugs."

The maintenance of pay records can be done just as well in the antarctic as in Washington and has the added advantage of not separating the individual from his records. Full cooperation is extended by the Navy Finance Center, and allotment changes may be made any time by message. NRAO Cleveland is well aware of the lack of mail facilities, and the Navy Comptroller Manual provides for late financial returns, even a year late.

There is a natural tendency toward familiarization between officers and men in an operation of this nature. This must constantly be combatted. Friendliness and impartiality are important. Friendliness of an officer toward an enlisted man must be tempered by the maturity of both. This is difficult to do when the officers live, eat, sleep, and work in close association with the enlisted men. Friendliness becomes familiarity if uncontrolled. Military discipline must be adhered to regardless of circumstances.

Recommendations

1. From an administrative standpoint, it is recommended that augmentations of summer group personnel be assigned on a TAD basis to McMurdo so that the command and organizational lines might be clearly defined.

2. In view of the lack of mail facilities during most of the year, it is recommended that all personnel to be assigned administrative and personnel duties become completely familiar with the naval communications system insofar as the drafting of messages is concerned. This is the only means of carrying on even routine administrative matters between Antarctica and activities of the Navy Department.

3. It is recommended that chains of command be so established as to place the senior officer of the antarctic units at the same station that functions as radio central. This move would eliminate thousands of man-hours in administrative and communications matters.

("Recommendation No. 1 was defined by establishment of Antarctic Support Activities during Deep Freeze III. No. 2 is not peculiar to Antarctica. No. 3 was solved with the closing of Little America."[12])

BASE OPERATIONS

McMurdo

Camp Operations

With the exception of a period during the winter, the work routine of the base was on a 24-hour basis, with two 12-hour shifts. This was caused initially by ship off-loading and camp construction, and later by runway construction schedules. The normal day started at 0550 and ended at 2200. There was little idleness. On Saturday nights and Sunday mornings, work was carried on with reduced crews to allow men to enjoy the happy hours and the church services. Special events were relayed through an extensive intercom system to each working space and barracks. There was a natural tendency for each hut to form cliques. This tendency had to be combatted whenever possible.

Due to manpower shortage every department was stripped to a bare minimum to furnish men to construction crews. Much of the camp maintenance was accomplished after normal watches. The utility men and electricians not only had the powerhouse watches, of 12-hour duration, but also had to maintain the camp stoves, snow melter, galley utilities, and camp electrical system. Because of the severe shortage of manpower, every man had to be utilized to the utmost, frequently out of rating and in several endeavors. The result was a slackening of organizational lines between departments.

From a wintering population of 93, the base, designed to support an additional 80, suddenly ballooned to 350 in the spring of 1956. Instead of a single tight organization, four administrative elements materialized overnight. These were: Task Force Forty-three, Air Development Squadron Six (VX-6), 52nd Troop Carrier Squadron, and MCB (Special). In addition, an element of MCB-ONE was aboard to augment MCB (Special). These personnel were immediately integrated into the camp organization and filled vital billets left vacant by MCB (Special) Det One personnel departing shortly for the construction of the South Pole Station. Too, the press and public relations department blossomed into a major operation requiring a special building for such personnel. By their presence, the communications workload doubled daily. Another factor contributing toward confusion was the indoctrination of MCB (Special) relief personnel and the transfer of responsibility to them.

In late December 1956, the task force ships arrived, bringing with them the balance of MCB-ONE and a few Detachment BRAVO people. At this time, the transfer of responsibility to key BRAVO persons was commenced. This was an essential process, but it did not augur well organizationally. The process of indoctrination tied up much needed workers and resulted in much duplication and some confusion, as it occurred at the peak of the summer workload. The most serious and demanding tasks were airfield maintenance and ship off-loading. Unfortunately, these tasks were in direct opposition to each other, as the same personnel and tractors were required for both jobs.

Administrative Support

The Naval Air Facility at McMurdo provided administrative support to the following: MCB (Special) and AirDevRonSIX wintering-over groups, MCB-ONE summer support personnel, ComNavSupFor Antarctica and Staff, Air Force personnel, news correspondents and visiting VIP's, and military and civilians in transit from Byrd, Little America, and South Pole Stations. In Deep Freeze II, McMurdo also maintained service records of personnel at outlying bases and provided clerical support for the various NAF departments. One wintering-over yeoman was available during Deep Freeze II and III to attend to the many and various needs of the foregoing.

Command Designation

The officer-in-charge at McMurdo was not designated as such by the Secretary of the Navy and therefore had no disciplinary power over the MCB (Special) officers and men assigned. However, the commanding officer, MCB (Special) was aboard during Deep Freeze II so this was not a problem. The VX-6 personnel were under the operational control of ComNavUnits, Antarctica, who was at Little America, and therefore the NAF officer-in-charge had no disciplinary power over them.

This resulted in differences of opinion on various matters, but the spirit of cooperation prevailed and they were arbitrated as necessary. No great problems developed, but this chain of command did tend to make a loose organization.

OOD and JOOD

The OOD/JOOD desk was manned 24 hours a day throughout the year. The OOD was rotated daily among the officers, and the JOOD was a 12-hour watch for two permanently assigned men. This desk was the nerve center for the camp operation, and the person on duty was responsible to the officer-in-charge for maintaining a record of all personnel reporting to and departing the NAF, implementing the Plan of the Day and normal camp routine, expediting emergency repairs, supervising the cleaning of heads and administrative spaces, dispatching personnel and cargo vehicles, making berthing assignments, supervising the fire and security watch, and setting the storm conditions.

During January through March 1957, the OOD desk also acted as the voice communications center with an ANG-9 transmitter and radio on a circuit with ships, runway tower, air ops, and radio equipped vehicles. Such a circuit is necessary for monotor and control during unloading and continuous air operations. During the winter months, the ANG-9 equipment was removed from the OOD/JOOD office and the air ops duty desk guarded this circuit.

Public Information

During the winter months the CHINFO was informed of all the activities that took place in the various departments. During the winter, every individual who wintered over was interviewed concerning his work and experiences. This was relayed in the form of a weekly news release, and by the end of the antarctic winter a factual report concerning personnel and their activities could be compiled from the information obtained in this manner.

News reports of an unusual nature, such as outstanding events or happenings, were made immediately and particular care was given to the presentation of facts and names so as not to confuse, misinform, and worry the public, especially the families of men concerned. In releasing news reports, it was felt that Antarctica, its vastness, its weather and everything contained therein, together with the projects carried on in fulfilling the mission of the base were interesting and novel enough to any reader.

An informal weekly newspaper containing stateside news, happenings at other bases, and mostly local gossip, with some very popular select feature articles by base personnel, proved to be a tremendous success. Each week all hands looked forward to the receipt of this publication.

The station amateur radio facilities also supplied outside news and even a newspaper prepared by Radio Amateurs of Greater Syracuse. The latter was received via the facsimile transceiver. All interviews over the amateur radio facilities were conducted according to the policy set forth by Task Force. Photos of persons and activities were also transmitted to Radio Washington by the station facilities.

During the summer operation the McMurdo public information program took on an entirely different aspect with the arrival of the staff PIO officers and the civilian press. Even though the tempo of camp activities increased and newsworthy events were taking place not only daily but also hourly, a minority segment of the press complained of the absence of newsworthy material. However, the unlimited cooperation of station personnel and the unrestricted use of facilities extended to the press representatives was obvious at all times and this did establish a good relationship which existed at all times. It is felt that McMurdo was thoroughly covered by the press.

Recommendations

1. That personnel, both winter and summer, be assigned directly to ComNavSupUnits. If an organized unit is assigned for the summer period, it is absolutely imperative that it be accompanied by its own officers and administrative personnel. It should also be given a clear-cut mission independent of the base unit.

2. That the first, and probably the second, C-124 arriving in the spring have on board only summer support and relief personnel, and cargo requested by the officer-in-charge. Base personnel must be increased about 80 to 100 to adequately support around-the-clock air operations, and these personnel need to be on board about one week prior to the commencement of such operations for proper check-outs and training.

3. That the officer-in-charge, NAF, be designated by the Secretary of the Navy.

4. That all wintering-over personnel report in writing to the officer-in-charge, NAF, for temporary duty.

5. That the station complement be increased by approximately 20 men, exclusive of the VX-6 detachment, for a workload similar to that of 1957.

6. That all wintering hospital corpsmen, photographers, and aerologists be permenently attached to the support unit and not to AirDevRon SIX.

7. That sufficient radiomen be assigned to handle all circuits 24 hours a day with eight hour watches, plus 10 percent for sickness and camp support duties and watches.

Little America

Camp Operations

Little America V was commissioned on 4 January 1956, at which time construction was just commencing. Crews were working around the clock on two 12-hour shifts. By 16 January, eight buildings were completed, and it was considered more advantageous to use one 12-hour shift. The last outside work was accomplished in April, by which time sixteen buildings and three fuel tanks had been completed.

The administrative office at Little America was located in a Jamesway hut. The desks and file cabinets were in excellent condition and were ample for all requirements. The typewriters were old and in poor condition, but were kept operational through constant maintenance. The mimeograph machine was in fair condition and sufficed; however, much repair was required due to excessive use.

A 24-hour fire watch was established, with two men on 4-hour watch at a time. This watch was also responsible for fueling all tanks for heating units and keeping the three snow melters filled. The base was divided into zones for purposes of fire fighting, and personnel were assigned fire stations. Periodic fire drills were held to familiarize all hands with their fire stations. Reveille was at 0630 and Secure was at 1630 on regular work days. This schedule was increased as necessary with the return of daylight and the digging out of materials and equipment. Basic camp maintenance necessitated a regular work schedule, and other operations such as communications, commissary, aerology, sick bay, etc., were carried out on a watch-standing basis. Everyone had two 2-week tours of mess cooking.

Because of the great amount of work and the transportation and weather difficulties of traveling to and from the field each day, the aviation personnel were moved to Kiel Field. The watch schedule was rather severe due to the small number of personnel involved. Two men were on watch each night relieving each other at 0200. A watch was relieved every 2-1/2 days. Even with the more complete

isolation and eating, sleeping, and working closer together than any other group during the winter at Little America, no serious personnel problems or personality conflicts were encountered.

Public Information

Public Information Office responsibilities were assigned to the chaplain as a collateral duty. A news roundup was submitted every week and spot news releases were prepared whenever appropriate. During the summer period the PIO acted as liaison between news correspondents and the station command. This involved providing working space for correspondents, briefing them on operations, clearing press copy, and assisting them in every way possible.

The PIO edited a monthly Antarctic News Letter, which was disseminated to all U.S. antarctic stations via radio. The PIO organized and supervised the publication of a weekly station newspaper, "The Penquin Post," and supervised the organization of a cruise history book to record the winter's activities at all U.S. antarctic stations. The PIO worked closely with the photo lab to insure optimum coverage of all newsworthy events.

Disbursing and Credit System

The original plans for a financial system for Deep Freeze II indicated continuation of the Deep Freeze I cash system and maintenance of pay records. This system apparently worked well at Little America and McMurdo, although it required more administrative personnel than if these functions were not present. The problem of one disbursing officer for an entire continent for Deep Freeze II, with innumerable deputies and attendant pay record maintenance, etc., was recognized as exceedingly difficult to resolve using normal disbursing methods. At the five new bases, manned by young and new naval officers, training personnel to be able to perform those functions without any direct supervision appeared unreasonable and impractical.

A credit system was therefore devised to eliminate any need for cash or pay records. This system was approved by all interested commands and bureaus. The system provided for all pay records of wintering-over personnel to be maintained at CONUS activities and for all necessary changes to be made by radio message from Commander Naval Support Units, Antarctica. Each person was given an allowable credit amount for each month, dependent upon the undeducted cash accrual remaining on his pay record upon departure from CONUS. This allowable credit was used to make ship's store purchases and pay for messing, if chargeable. Civilians were granted a flat $75 monthly credit. All purchases and charges were written on a form and signed for by the individual concerned. These credit charges were to be collected, after the wintering period, by the disbursing officer holding the individual's pay record.

The credit system worked very well all year at the smaller bases (Byrd, Pole, Ellsworth, Hallett, and Wilkes). The system worked well at Little America and McMurdo during the wintering period. A minimum of two administrative personnel were saved at the two large bases and at each of the other five bases, all of whom would have been required had a normal cash and disbursing system been used. However, the disadvantages of the credit system at Little America and McMurdo during the summer operations were great. With a large group of transient personnel arriving and departing each summer, it was impractical, inefficient, and resulted in poor morale to extend the credit system to include summer transient personnel.

The greatest difficulty and confusion experienced in the disbursing area lay in the per diem on TAD orders, the many types of orders issued to individuals, baggage allowances, mess charges, questions of permanent duty station and home port, field duty, snack charges, etc. Some personnel were on permanent change of duty orders, some TAD, and some TD; later some TAD orders were canceled and personnel returned to CONUS on permanent change orders. The loss of per diem resulted in some personnel being placed on health and comfort issues because all of their regular pay was alloted to their families. Flight pay was authorized for aviation personnel and observers although not performed because of lack of aircraft availability, but no provision was ever made for parachutists who could not jump for the same reason.

Recommendations

1. That action be taken to organize and clear up the entire area of travel allowances, special pay, mess charges, and types of orders in Antarctica.

2. That the credit system should be used at McMurdo only during the wintering-over period.

3. That pay records of all personnel at Ross Sea bases should be maintained at McMurdo during summer operations.

Byrd

Administrative and clerical demands at Byrd Station were minimal due to a small military complement; only health records were held. The officer-in-charge, who was also the medical officer, handled all clerical work.

During the first month, a 24-hour rotating OOD watch was established by the construction crew, employing three CPO's. Upon arrival of all wintering-over personnel, this watch was discontinued and all pertinent information was passed directly to the officer-in-charge.

Public Information

The duties of PIO were given to one of the enlisted men at the beginning of the year, but due to the heavy work schedule he requested to be relieved. The station scientific leader, who had experience in journalism, was given the job.

Monthly news releases were designed to present an interesting story in as brief a form as possible. The names of all personnel were released in various news items one or more times. At the first of the year an attempt was made by the radiomen to copy CW press and publish a station newspaper; but as the communications load increased and radio conditions grew worse this had to be discontinued. The antarctic news roundup, which was sent to all stations with news compiled from all other stations, was very much enjoyed.

Credit System

All transactions followed the credit system outlined by the detachment supply officer. However, in the absence of the designed forms, records were of an improvised nature. No disbursing was available, which at an isolated station is felt to be a decided advantage in the interest of each man, by preventing theft and gambling.

South Pole

Administrative and Clerical Conditions

All administrative work, including clerical, fell of necessity upon the OIC. A yeoman would have been of great value and would have freed the OIC from much of the routine administrative work for more important duties. Were one to be provided for a small base, he should also be able to double as photographer where none is assigned. No manuals, instructions, notices, or standard forms were provided for Deep Freeze II. BuPers Manual and standard personnel forms should be provided.

Office space, though somewhat limited, was adequate for the needs of both military and scientific personnel. Office equipment was extremely limited. Items most needed but not available for Deep Freeze II were typewriters, a mimeograph machine, and file cabinets. Expendables were also in very short supply and, without the availability of IGY office supplies, would have been critical.

Public Information

News releases were sent out covering both the military and scientific aspects of activities at the station. It is difficult to report on matters at an isolated base, as there seems to be little excitement during most of the year, one week appearing

much like any other. Often, what is newsworthy does not seem so to those involved. A conscious effort was made to adhere to concise statements of fact rather than indulging in the overdramatized strings of superlatives. Information received at the Pole was extremely sparse. It is highly recommended that there be a much greater exchange of information among the various bases, and that the Task Force periodically provide information on rear-echelon activities.

The influx of correspondents during the summer created unnecessary problems in the support of numerous additional personnel. Press coverage should be done on a pool basis, with a minimum number of correspondents and photographers actually going to the Pole. The presence of a large number of nonproducing transient personnel actively hampers essential operations.

Credit System

The credit system was used throughout the year at the South Pole and was found to be very satisfactory in all respects. The fact that neither ledger sheets nor tally cards arrived for the Deep Freeze II group made the accounting more difficult but did not impair the system. Sheets of ruled paper were used in lieu of ledgers, and it was found that throughout the year only one page per man per month was necessary.

Ship's Store

Ship's store was set up in the grid south tunnel in late January 1957. The store was made of 64-cubic-foot crates, two high, with the upper crate turned face inward to act as storage space. The entire area was covered with tunnel roofing. The usual temperatures in the South Pole ship's store was -50 to -65 F throughout the winter. Rationing of items was necessary in the case of film and souvenier items only. It is recommended that the supply of souvenier items be increased greatly to supply items which are suitable for use as prizes. Items marked with the name "South Pole" would be particularly good sales material.

Summer personnel (that is, VX-6 and civilian correspondents) were served from ship's store only during the second summer when a plane was grounded for a number of days. Items signed for in the usual way were recorded and the totals transferred to the individuals' credits at McMurdo ship's store. No cash was taken at the South Pole ship's store.

Beer was dispensed once a month at a limit of one carton per man without increase or decrease during the year. The only exception was if a man wished to buy a case for community use at other times than the specified sales date.

Recommendations

1. A locked file would help considerably in keeping records organized and secure.

2. Careful organization in respect to credit limits and meal charges would add greatly not only to the accounting but also to the morale of the personnel at the small stations.

Hallett

The administrative duties of this station were handled by the officer-in-charge and the radioman. The records and logs were kept by the officer-in-charge. All personnel records, except individual health records, were maintained at McMurdo and returned to the officer-in-charge prior to transfer from Cape Hallett.

Due to the limitation of personnel, no OOD or JOOD watch was designated for the station. In all instances when an OOD was required, the officer-in-charge was contacted.

Only two news releases were sent out from this station. Because of the small number of men there was very little activity other than daily routine, and it was decided not to write any news releases unless there was something unusual to say.

Wilkes

Administrative and Clerical Conditions

The administrative system of an isolated base can be very important. The desirable degree of formality in a military organization will depend upon many factors, as will the degree of intimacy and amount of intercourse between officers, enlisted men, and civilians. This is a subject which deserves much careful study. There will be difficulties whatever course is chosen, but probably an official policy would be accepted better than personal edict.

The administrative office space provided for the scientific leader and the officer-in-charge was barely adequate. Official publications received were very inadequate for the administration of a remote station. This shortage was very noticeable in the area of supply and personnel. It is recommended that an allowance of publications be set up for remote stations, since isolation magnifies the need for them.

Clerical supplies received were not adequate. A very real need for a small duplicating machine was experienced, and one unit could have been used for both military and scientific business. Office furniture was adequate for the administrative office, but not quite adequate for other spaces. In some cases desks and work space had to be locally fabricated. Filing cabinets were supplied and were generally adequate; however, a need was felt for at least two more.

OOD and JOOD

All functions of OOD and JOOD were assumed by the officer-in-charge, and no watches as such were stood.

Public Information

A bi-weekly news message was sent out by official Navy communications. It contained items of interest about personnel and happenings at Wilkes Station and was primarily of interest to the families of men wintering over. The releases were well received by the dependents and contributed considerably to their morale and peace of mind. It is recommended that newsletters be forwarded to families as soon as a man reports for Deep Freeze operation. Newsworthy events of a more immediate nature and with a wider field of interest than those noted above were reported by Navy message shortly after the event occurred.

Disbursing and Credit System

The only system used at Wilkes was the credit system. This system requires little training or intelligence to use and appeared entirely satisfactory from the point of view of the wintering-over personnel. The elimination of cash from a polar camp is felt to be very desirable, since it eliminates all worry about loss and greatly reduces gambling tendencies. A great deal of time was spent in attempting to make the system balance perfectly, but if perfect accuracy is not required the system can be easily checked. The ship's store was opened daily and operated by the officer-in-charge. It is recommended that sales of candy and tobacco be entirely by the carton, as unit sales considerably increased the amount of work by the storekeeper. Almost all of the men expressed concern for their pay records, as there was a general complete lack of faith in absentee administration. This was also true concerning the service records.

Ellsworth

Most administrative and clerical work was done in the rooms of the officers-in-charge. Office supplies were adequate for all clerical work carried on at the station. Minor repairs were required and successfully effected keeping all office

equipment in an operational status. Most failures of this equipment were due to use by inexperienced personnel. Additional cushioned desk chairs would have been an asset, as sufficient numbers were not issued for all desks.

Upon arrival, it was deemed necessary to assign OOD's with the primary responsibility of base security. In order to maximize fire safety, a fire watch was established under the direct supervision of the OOD. The OOD normally stood a 24-hour watch, coordinating base operations during the workday and remaining on call during the off-shift.

One of the officers from AirDevRon SIX was appointed Public Information Officer. He was responsible for the collection and dissemination of newsworthy items. All personnel so desiring were covered in Public Information news releases.

Recommendations

1. That a selection of items, suitable for welfare and recreation prizes, be available in the ship's store.

2. That stationery with the name of the specific base as a letterhead would be a far better sales item than the antarctic seal stationery.

3. That beer and shaving items be reduced. Stamps, candy, film, and souvenir items should be increased. Alarm clocks, underwear, nail clippers, and camera equipment could be added.

WORK FEASIBILITY

McMurdo

There is no such thing as a work feasibility chart for this area. However, as data becomes available with each succeeding operation in McMurdo Sound, some form of chart may be constructed. The following data will be of some use to planners; however, this kind of data, based on limited time and experience in this area, must be considered as a guide and not absolutely reliable. The data collected during four seasons may not apply to the following season.

Throughout most of the period of isolation in the winter of 1956, many of the camp personnel were required to work outdoors. From March until the end of May, construction crews were engaged in completing camp buildings and power lines.

From May until July, outdoor maintenance, gathering snow for water, handling of provisions, distribution of fuel, and preparation of material and supplies for the South Pole Station kept many outside. From July on, preparation of a runway 1-1/2 miles from camp on the bay ice occupied all who could be spared from other tasks.

On 21 April the sun rose for the last time until 21 August, and in the intervening four months, short twilight was the only available natural illumination. Outdoor work proceeded with artificial light. Temperatures fell steadily until September. During the sunless period, the usual reading in the camp lay between 20 and 40 degrees below zero. The extreme low was -76 F at the ice runway. There was almost constant winds of at least 20 mph and frequently the velocity rose to 60 mph or more. Falling and drifting snow made visibility poor and added to the discomfort of being outside.

In spite of these rigorous conditions, personnel adapted themselves well and were able to work outside on all but a few days. The bulkiness of the clothing made working slow, but discomfort and injury from cold was minimal. One- or two-hour work periods, followed by a few minutes of relief in a heated hut or wanigan, permitted work on a twelve-hour day basis without undue hardship. Except for a six-week period in midwinter, working hours were long and the work week six or seven days. On this schedule, by the end of the winter, chronic fatigue was evident in all hands.

Certain groups worked indoors a good deal of the time. Mechanics, steelworkers, electricians, storekeepers, cooks, and administration personnel, when occupied by their basic skills, faced working conditions substantially the same as in temperate latitudes while working indoors. One significant difference, however, was the problem of ventilation of shops where toxic fumes were present, such as carbon monoxide in the garage and zinc fumes in the steel shops. The low outside temperatures made it difficult to maintain comfortable inside temperatures and at the same time provide adequate ventilation.

A characteristic of life in the winter camp was that men often worked at jobs other than their rated specialties. Cooks and corpsmen worked as mechanics and steelworkers, photographers and yeomen worked as equipment drivers, etc. This was necessitated by the pressing demands from time to time to get certain pieces of work accomplished. In general this challenge was met enthusiastically by all hands, and it was noted that the more rigorous outdoor tasks were preferred by most.

Little America

Floodlights were jury-rigged from R4D landing lights and mounted on roofs for outside work during the night. It was found that by taking special precautions and being very careful, outside work could be accomplished at -65 F. Of course, men could not work outside at that temperature for very long at one time ("approximately one hour"[13]) even with the aid of good parka hoods and face masks. Consequently, necessary outside work was done in shifts. Very mild cases of frostbite were not too unusual; however, no serious cases occurred. "Weather conditions in general are very conducive to a building program during the summer months at Little America. The sun shines 24 hours of the day and night during the latter part of December and the month of January. During this period the temperature may rise to between 30 to 35 F and drop to between -5 to 10 F. During the summer period there are very few snow or wind storms, and the weather generally is good."[8]

Byrd

Local climatic conditions greatly influenced the feasibility of outdoor work at Byrd Station. During the daylight period approximately one day out of every two was lost due to bad weather, wind being more significant than temperature. Wind below 15 knots created little difficulty apart from the wind-chill effect. Above this figure it caused blowing snow to hamper the vision of vehicle operators. In the dark period, the likelihood of losing sight of the station lights made it necessary to restrict all outside excursions, while indoor work was on the same basis as in any temperate zone.

Beardmore

Living conditions at the Beardmore Station were similar in all respects to those at McMurdo during the initial summer season.

South Pole

Data is still too scarce to predict work feasibility at and around the South Pole. Thus far, the months of occupation of that remote location are limited. The records prior to Deep Freeze I are scanty, being limited to two parties (Scott and Amundson) who visited the area for a matter of days.

The conditions of the Polar Plateau at the South Pole between 20 November and 31 January were not too severe for construction. The winds proved to be extremely mild, and the temperatures were not severe. Varying from -20 to +5 F,

the temperatures were not unlike those to which the construction party had become accustomed in the spring and fall at McMurdo Sound. Storms were few. There was 24-hour daylight. The altitude of approximately 9700 feet added the rigor of low oxygen tension and required a period of acclimatization before full work capacity could be attained. After seven to ten days, all hands noted gradual improvement in exercise tolerance, but even at the end of the construction period, physical exertion was found to be much more tiring than at sea level. With more extensive support facilities the period suitable for construction could be lengthened. It is difficult to say what temperature is too cold.

From the human standpoint, no conditions were encountered during Deep Freeze II under which outside work could not be accomplished. Under extreme conditions, endurance was quite limited, particularly if any degree of manual dexterity; and hence the wearing of light gloves was required. Where manual dexterity was not required and personnel could remain fully protected by heavy clothing, no time limit was found with personnel who remained physically active. When the seismic tunnel was being dug, men were working all day in about -80 F weather without undue discomfort. Two men spent up to four hours walking around in -95 F weather, with a fair wind, and gave up more because of fatigue than cold.

One thing is certain, the men will outlast the equipment in severe cold. Technology and equipment have not been developed to work and carry on positive performances at -65 F, which appears so often as the limiting temperatures. At -65 F, the men can keep some work going, but the machines break down to a point where economics, unless in the utmost emergency, forbids work at these temperatures.

Without exception, the limiting factor in outside work was the machines, not the men. An arbitrary temperature of -50 F was assigned as the approximate safe lower limit for extended operation of the D2 and the weasel. By keeping the vehicles stored in the garage, however, they could be used without great ill effect for limited periods of time (fifteen minutes to an hour) in temperatures down to the -90's. In the -60 to -70 F range, moderately extensive vehicle operation is possible; below that it becomes more and more limited.

The real problems of construction at the South Pole, as at any other remote and isolated area, are ones of logistics. Wind, in addition to temperature, must always be considered. At McMurdo the winds are much stronger than at the Pole; consequently, although it is warmer there, the efficiencies of the construction personnel were believed to be less at McMurdo than at the Pole.

Due precautions must always be taken against frostbite, especially whenever there is a noticeable wind. While minor frostbite, especially of the nose, was commonplace, no severe frostbite injuries were experienced. The possibility is always present, however, that such could occur particularly through carelessness. Frostbite of the hands and feet is especially to be guarded against; being covered, freezing here is not readily noticeable, as it is on the face.

Under conditions where life centered around an established base, greater or lesser amounts of outside work were possible all year, with sustained work only from about mid-October through mid-March. This is a broad generalization, however, and will vary with the nature of the work to be done, personal cold tolerance, and actual temperatures and winds. Some men definitely withstood the cold much better than others; and, in any given individual, tolerance varied from one occasion to another.

Recommendations

1. That all personnel be indoctrinated on the dangers of serious frostbite, and in the proper utilization of clothing.

2. That better clothing be developed for work requiring manual dexterity under conditions of extreme cold.

3. That mechanized equipment be developed which is capable of unrestricted operation at temperatures down to -100 F.

Hallett

From the personnel standpoint, this station encountered very little difficulty in accomplishing the job assigned. However, it is believed that more personnel could have been profitably utilized in the various rates to decrease the heavy workload. It was found that men properly clothed, regardless of conditions, could do almost any job. The time involved for any specific task was lengthened due to the cold. The greatest single weather factor to hinder working conditions was the surface wind.

Wilkes

From a personnel standpoint, no conditions were encountered under which some outside work could not be accomplished. Extreme cold at Wilkes Station was not a problem; however, the frequency of blizzards with the accompanying blowing snow were. Only work of an emergency nature could be undertaken during these times

and then only in an area in which personnel were intimately familiar. Very poor visibility, wind chill, and flying objects made work at that time very hazardous. The buddy system was and should always be used by personnel working under these conditions, as frostbite of the extremities is a strong possibility. For productive work to continue at all times, work should be planned with consideration given to the seasons and the possibility of storms.

Lack of mobile equipment especially designed for cold-weather operations hampers operations during cold weather. Experience at this station was that at temperatures a few degrees below zero, engines became difficult to start and operate. Defects in equipment that during warmer temperatures would not have interfered too much with equipment operation would become quite serious in the cold weather. Upon the return of summer, a distinct and noticeable improvement in the operation of mobile equipment was apparent.

Ellsworth

The environmental conditions, as could be expected, did affect the quality and quantity of work that could be done outdoors. However, the difficulties encountered by snow, cold, and darkness were not excessive, and all necessary work was accomplished. Heavy cumbersome clothing made some jobs tedious and longer to perform. In a few instances the cold, by causing frostbite or arthritis, necessitated the substitution of individuals on certain jobs like snow melting.

WELFARE AND RECREATION

McMurdo

Morale

During the period of darkness during Deep Freeze I, the loneliness, drudgery of hard work, severe cold, the thought that all avenues of escape were impossible, close contact with one another, etc., all weighed heavily on the minds of the men, but each took it in stride. We were blessed with so many fine personalities that each man took it upon himself to be a chaplain to his buddy, and everyone shared responsibilities in the work of the survival of the team.

Major complaints contributing to a slight loss to the otherwise high standard of morale, were: a meager supply of hobby materials, lack of variety in the preparation of food, lack of light novels, magazines, and record players, and a heavy work schedule with not enough free time for relaxation. Men were not allowed to

bring musical instruments or hobbies of their own. Under more normal working conditions a well-planned education program would have been successful. Perhaps the heavy work schedule and the pressure of much to be done was the reason that very little interest was shown intellectually, as was evidenced by very little heavy reading and a great demand for the lighter novels. There was no mail service from March until October; however, this was compensated for somewhat by the "Class Echo" messages and ham radio contacts.

The morale of the officers and men at the Naval Air Facility, McMurdo Sound, remained exceptionally high throughout Deep Freeze II. Everyone was not always a cheerful and willing worker, but neither did a large number of persons ever become remorseful or sullen or completely stop doing their share, nor did anyone become that way for more than a day or two. The intense activity of the present and/or the anticipation of the future kept all hands busy and interested through the year.

The basic reason for the consistently high morale is believed to be that the officers and men were volunteers and, in general, well screened. Also, the camp life was made as pleasant as possible under the circumstances; movies were shown daily; living quarters were adequate during the isolation period; there were no restrictions on the sale of beer; bingo games were played once weekly; all-hands parties were organized every Saturday night; a weekly paper was published with Stateside, Navy, and local news; hamgram service from and to McMurdo was excellent; the mess hall was always open for coffee and snacks and the four meals served daily were consistently excellent; a large selection of hobby craft material was available; the library had a large selection of fiction and nonfiction; a recreation building with shuffleboard, ping-pong and pool tables and a gym with wrestling mat, weights, and sweat box was available; the aerology watch operated a low-power radio station with continuous music; a hi-fi set with an excellent collection of good music was available in the library; and the services of a doctor, dental officer, and chaplain were always available.

The morale of the men during the summer season sometimes dropped, for they worked at least 12 hours a day seven days a week. Also, the camp was so crowded that recreation facilities were dispensed with, except for the movies; and they were overcrowded. Living spaces were jammed, especially the summer quarters, which held 24 to 40 men in a 20- by 48-foot building. The buildings were poorly ventilated for such a number, and there was little or nor storage space for individual gear. The around-the-clock working schedule prevented the barracks from ever being quiet.

At the end of the tour, many of the McMurdo wintering-over personnel felt that their efforts had not been appreciated by the higher echelons of the Navy; however, very few let such feelings affect their output. This general feeling was caused by one or more of the following:

1. In September and October 1957 the news from home via ham radio and letters quoted a ComNavSupFor Antarctica News Release that all Deep Freeze II wintering-over personnel would be home by Christmas. This was great for morale until the arrival of the Task Force in October when it was flatly denied, and then the morale of some was on the deck. Though almost everyone had left McMurdo in time to be home for Christmas, and this was appreciated, the morale damage through an operationally crucial period had been done.

2. The comptroller's decision not to pay per diem to wintering-over Deep Freeze II personnel was a low blow to everyone, and feelings ran the full range from anger and disgust to the psychological "that's the way the ball bounces" attitude.

3. Although the comptroller had ruled out per diem for wintering-over personnel, the officers were charged $70.00 per month for subsistence ($2.50 per month for snacks).

4. Permanent change of duty orders were received by almost all people while still on the ice. Relatively few received their first choice of duty, and it was quite a shock to some who were counting heavily upon the first preference. Almost everyone was under the impression that a wintering-over period was considered as two deployments of six months and that first preference would be given if the billet was available irrespective of shore and sea duty time requirements.

5. Upon arrival in New Zealand and CONUS, many Deep Freeze II persons were broke and could not get paid because they had drawn advance pay and/or per diem. This reopened or magnified the per diem question again.

During the isolated period of Deep Freeze II, family contacts through the medium of the amateur radio facilities proved to be a most valuable asset. For the greater part of the year, a systematic family contact program was in effect. This was disrupted only by extreme workloads of the communicators, by unfavorable atmospheric conditions, or by the breakdown of equipment. The cooperation and service of amateur radio operators was priceless. In cases of family deaths or serious illness, contact was maintained through these channels. Also, through these media many family problems were handled with the aid of a third agency, such as another chaplain, the American Red Cross, or the Navy Relief Society.

During the antarctic travel season, being able to receive and send mail was one of the greatest morale boosters. Without a doubt, mail was the most important and the most desirable item as far as promoting the individual welfare and attitude of the men. The mail service to McMurdo was excellent, with only a few minor complaints being registered. However, since McMurdo is actually the gateway to the Ross Sea side of Antarctica, it is believed that the establishment of an official post office at this base is essential for better and faster mail service, not only for the men that are stationed at McMurdo but also for distribution to the other bases.

It must be noted here that in spite of the great desirability of receiving mail, for some, unfortunately, its arrival with unfavorable news also created problems. However, most of these were resolved in time, with the exception of one or two which had to be handled immediately, and evacuation was recommended.

Attention must also be called to the fact that to the wintering-over party, fresh milk and fresh fruits and vegetables were important items. These were had rarely, even at a time when it seemed that it was possible to receive them. It does seem that provisions could be made to establish a certain priority for these desired fresh foods, which though not essential, are important to the welfare of the men who were without them for a long time.

After the long period of isolation, the influx of personnel in great numbers did seem to affect the group that wintered over. One effect was salutary and wholesome; new faces, new friends were most welcome. The other effect, not too good, seemed to relegate the wintering-over group to a relatively minor role in the life of the camp which had been their home for almost a year. Some wintering-over personnel felt a little discouraged when new arrivals, either because of misinformation or lack of consideration, became highly critical of them.

Recreation

Because of the long working hours during Deep Freeze I, time for recreation was limited and off-duty hours were used by many simply for rest. Movies were shown in the mess hall, their frequency varying from one to seven times weekly depending upon the pressure of the work schedule. A library with a good selection of books was available and was much used. A phonograph with an interesting collection of records was available. Painting and some model building occupied some personnel. During the winter, weight-lifting and table tennis were enjoyed. As soon as daylight returned, many men took to the surrounding hills for skiing and sledding; all of this in spite of a constant 12-hour workday. Several went on camping trips and on hikes. Several weasel and dog team trips were made to Cape Evans and Cape Royds.

On Saturday evenings, a party for all hands was held in the mess hall, at which spirits from the medical supplies were distributed to all who desired them. Frequently, these weekly parties included entertainment organized by the chaplain and comprising a play, variety show, or musical skit featuring various personnel of the camp. These Saturday evenings were anticipated happily by all hands and were an important morale factor. The mess hall was always decorated and special food was prepared. On various occasions recorded music was piped over the P.A. system, utilizing a tape recorder.

Education

The education program was planned and executed with the aim of providing maximum educational benefits for the needs of the men concerned. The program relied on two basic sources of material, the Navy correspondence courses and the U.S. Armed Forces Institute self-teaching courses, which not only helped the individual promote his Navy career but also furthered his personal education and knowledge.

Prior to departure for Antarctica all Deep Freeze II personnel had the opportunity to order the desired or necessary courses and, with only one or two exceptions, these were made available to them at the Station Education Office. The enlisted men Navy courses and the USAFI tests and manuals were made available through this office. The Navy officer-level courses were sent to the individual directly by the Correspondence Course Center. As each man checked out the desired course or courses (the number was not limited), the subject was advised that where no formal classes were held, additional information and instruction could be obtained from qualified individuals (both officer and enlisted) who volunteered their services in this capacity.

A surprisingly large number of courses were ordered and even though it was obvious at the outset that not all would be or even could be utilized, nevertheless it later proved to be a consoling thought to the education officer and to the station command to know that these courses were available. And, even though it seemed that certain courses were superfluous, several men requested them and their opportune availability justified the cost and effort that was expended in bringing them to this isolated base. This also helped to contribute to the morale of the station.

The station library, made up of almost 1000 highly selected books, included many informative reference texts. It was a very valuable asset to the station's education program. However, its significance decreased considerably when the space used exclusively for reading and studying had to be shared for other purposes. This, without a doubt, was the greatest setback that the education program suffered. It is

strongly recommended that, in planning future operations, this problem be given serious consideration and that a high priority be established to allocate a space for this purpose.

Though it is impossible at this time to establish suitable criteria by which to judge the intellectual benefits and accomplishments of the individuals who took advantage of the McMurdo education program, it can be stated that the schooling opportunities afforded them obviously helped them advance in their Navy career. Almost all advanced in rate, some extended their enlistment, and others decided upon the Navy as a career.

Religious Program

During the hectic Deep Freeze I construction period, various buildings at McMurdo were used for Divine Services. Services were held whenever the men could get a moment to spare, morning, noon, or night. Late in February, permission was granted to build a chapel. Dedication was held for all hands just as the sun was disappearing over the horizon for the last time in five months. The chapel consisted of a half Quonset building with plywood interior. A vestibule and bell tower were eventually added. This was the first building on the antarctic continent to be dedicated exclusively to the honor and glory of God.

The Chaplains Bureau, Washington, D.C., and the Chaplains Aid Society of New York supplied all essential religious materials. The American Bible Society supplied Bibles and literature. An organ was obtained from the Quonset Point, Rhode Island Chapel, and a large crucifix and statue were donated by the Catholic Welfare Association of Providence, Rhode Island. An interested family of Providence donated a large upright piano and musical instruments. Two memorial plaques were hung in the chapel. One was dedicated to the wintering party, with each man's name inscribed as the men who built and dedicated the first chapel in Antarctica. The other was in memory of all those who gave their lives in the exploration of the antarctic.

During the long winter night, Roman Catholic and Protestant services were held every Sunday. A Protestant choir of sixteen voices sang each Sunday. Religious instructions were given regularly, and the chaplain was always available for counselling.

When the sun returned and work outside was resumed, a memorial to Richard Williams was built atop Arrival Heights. Twenty tons of rock were hauled by tractor and sled and a massive grotto was raised. Within the grotto was placed a large statue of "Our Lady Of the Snows."

Thanksgiving and Christmas were celebrated with the usual choral services and Midnight Mass. Trees and decorations were flown in by the Air Force. On Christmas Day, with eight ships in McMurdo, a general service was held on the ice with some 800 in attendance.

During Deep Freeze II, daily Mass was offered in the chapel at a time most convenient to the base schedule, both for working days and holiday routine. This varied with the workload of the seasons and the influx of summer support personnel. The Sunday and holyday schedule was maintained with the same consideration in mind. Catholic instruction classes were conducted twice weekly. Special devotions were held throughout the year. On 24 February 1957, the Catholic Bishop of Dunedin celebrated Mass at the McMurdo chapel. During the following summer, a Catholic priest aboard in the capacity of a scientist also helped with services. The station Catholic chaplain made pastoral visits to Little America, Hallett, Pole, Liv, Byrd, Camp Michigan, Byrd Tractor Train, and offered his services to the nearby New Zealand neighbors at Scott Base.

Sunday and occasional Protestant Divine Services were conducted by a lay leader assigned by the Protestant chaplain of Deep Freeze II. The response was not overencouraging. The attendance gradually dropped off. Frequent requests were made to have the Catholic chaplain conduct general services.

On 13 December, the injured Deep Freeze III Protestant chaplain who was being evacuated via McMurdo, was invited to hold a brief service at the station chapel. He never spoke to a more appreciative congregation. This was the first worship service conducted at McMurdo by a Protestant clergyman in almost a year. On 20 December, McMurdo was visited by the Deep Freeze II Protestant chaplain who conducted two communion services that Sunday. It is recommended that a more extensive program of exchanging stations be effected on future operations having two chaplains, Protestant and Catholic.

Provisions for worship by personnel of the Jewish faith were made and offered. However, this program was limited to personal private services.

General services were conducted by the Catholic chaplain on important occasions throughout the year. Memorial services were conducted on the occasion of the death of Admiral Byrd, as also for Deep Freeze II personnel who lost their lives in Antarctica. A fitting memorial plaque was placed in the chapel in honor of the six men who made the supreme sacrifice on this operation.

Other religious services that took place at McMurdo were the daily offering of the morning prayer over the base intercommunication system, special invocations and benedictions on various occasions, and blessings before the commencement of hazardous missions. A meal prayer plaque with appropriate thanksgivings according to the Protestant, Catholic, and Jewish faiths was placed in the mess hall and added much in spirit and decorum to the meals.

Having a chaplain available to plan and carry out the religious program proved to be an asset to the station. Even the New Zealanders at Scott Base benefited by McMurdo religious activities to which they were cordially invited and had occasion to participate in many.

The chapel, erected by personnel of Deep Freeze I, was without a doubt the most attractive interior space on the entire base. Deep interest, religious spirit, and personal pride of personnel helped to maintain and fittingly decorate the chapel for the various occasions and holydays. Its appearance was always outstanding and its atmosphere conducive to divine worship. Throughout the winter and summer the chapel was used not only for Divine Services but also for personal meditation periods. Maintenance and exclusive religious use of the chapel paid off. Gratitude was expressed on many occasions for the availability of such a place with a distinctive reverential and peaceful atomosphere.

Little America

Morale

Morale during Deep Freeze II was excellent at Little America. Not only is this the opinion of military and civilian leaders who wintered over, but summer visitors frequently made totally unsolicited comments on the high state of morale. This was achieved through the help of the following:

1. A full work schedule was observed all year, thus there was no excessive leisure time. The men realized the need for their skills and effort. Recognition was given for work well done. All hands had a sense of achievement, the satisfaction of accomplishing a difficult task.

2. Living conditions were better than anticipated. This included food, berthing, clothing, and ship's stores.

3. Excellent educational opportunities were offered. A wide selection of USAFI self-study courses and Naval Training courses was available. A series of lectures by scientists on various aspects of the International Geophysical Year was conducted.

4. Personnel were able to communicate regularly with families and friends via amateur radio.

5. Divine Services, both Catholic and Protestant, were held regularly in a chapel constructed by the men themselves. A full program was carried on, including Bible study classes, choir, religious motion pictures, and personal counselling.

6. All enlisted personnel who passed examination for advance in rate were promoted; none were cut by quota.

7. An active recreation committee carried out a varied program.

8. "News Roundup" public-information releases were submitted weekly for use in the Dependents' Newsletter and by the Fleet Home Town News Center. A systematic record was maintained to insure that all personnel were mentioned in news releases during the wintering period. A weekly station newspaper was published.

9. Special occasions were observed in traditional military manner. Each Friday at evening meal all personnel who celebrated a birthday during that week were honored guests, and all hands enjoyed birthday cake.

10. The personality and competence of those who wintered over was a definite positive factor in morale. In this respect, the careful screening of volunteers paid off.

Loneliness and isolation were the main opponents of high morale. One's surroundings and associates were always the same. All hands lived with the knowledge that they could not be evacuated in event of family emergency or for medical care, should such become necessary. Prolonged blizzards, when all hands were confined indoors, brought a general growing tenseness, moodiness, and impatience. The unceasing moan and wail of the wind was inescapable; the blowing snow created drifts which made inevitable the laborious shoveling out of entrances, passageways, and equipment. The extended period of darkness brought a certain dullness to personal morale, but it was so gradual as not to be noticed. Only when the sun returned, attended by a noticeable rejuvenation of spirit among all hands, was it apparent that morale had been a bit dull.

The greatest single blow to morale was the announcement of no per diem, after it had been authorized in orders and many had drawn it in advance.

Relationships between military and civilian personnel were somewhat delicate at first, as the two groups were evaluating and getting to know each other. However, within a reasonable period a good adjustment was reached and, with few exceptions, this aspect of morale was excellent all year.

Recreation

Adequate recreational facilities are of prime importance in helping detract from the boredom and monotony found at an isolated base such as Little America. The recreational facilities at Little America were not adequate during Deep Freeze I, and consequently the adjustment of the wintering-over party was made more difficult.

A recreation building was erected by utilizing leftover prototype building panels. This proved to be of inadequate size, and an additional section was built using panels earmarked for Byrd Base construction during the spring of 1956. On 1 October, the recreation building was converted into a temporary living area for incoming aviation and construction personnel. No recreational area was available at Little America during the period of greatest population at the base.

Movies were the most important form of recreation. The supply of movies was adequate to allow a different movie each day through late October 1956. The main difficulty in regard to showing movies was the lack of space for a theater after 1 October, when the recreation building was converted into temporary barracks. Movies thereafter were shown in mess hall, barracks, shops, etc.

The number and variety of books available in the library was inadequate. Paperback books were in almost unreadable shape by midwinter. There was no area set aside for hobbycrafts. There was great demand for such things as leathercraft and model crafts. An important means of entertainment to men at Little America was the record player and record library. The record library appeared adequate.

The major indoor sports available were ping-pong, cards, chess, and acey-deucy. Volley ball was played enthusiastically outdoors despite 20 F below-zero temperatures. The small number of indoor sports available was greatly curtailed by the loss of the recreation hall in October.

Parties were a favorite form of entertainment. Parties were held at least once weekly during the midwinter months. A buffet dinner and alcoholic beverages were served. Formal and informal entertainment such as skits, song sessions, and guitar musicals was provided. Study courses by USAFI and Navy correspondence courses were also available for off-duty hours. Ham radio, which permitted personnel to talk with their families via radio and phone patches, plus sending messages, played a large part in maintaining a high degree of morale.

The following recommendations are presented for guidance in the planning of future operations of this nature:

1. Space should be allocated for personal counselling which will give sufficient privacy to put personnel at ease and make the opportunity of coming for counselling more inviting. In Operation Deep Freeze I, counselling was often delayed until a location with a more than an average degree of privacy could be found. The ideal thing would be a separate building, even though small, which could be set aside and utilized for religious and spiritual activities during regularly scheduled periods.

2. Though the quantity of motion picture films and library books on an operation of this type is often limited, quality and variety are important factors to be considered.

3. Recordings of popular, semiclassical, and classical music are of great importance as a recreational item in connection with any operation where music is not readily available from usual sources of radio, television, and group activities.

4. Although outdoor games in the antarctic are limited, football, volley ball, and soft ball equipment should be obtained, as well as such winter sporting equipment as skis, ice skates, and sleds. All sorts of indoor games are valuable, with sufficient equipment being provided for the running of tournaments. Such things as ping-pong balls and badminton birds have a high usage rate and should be provided in sufficient quantity.

5. Hobbies and crafts which are fairly complicated and present more of a challenge are more valuable at an isolated duty station than ones which require little or no handiwork.

6. The editing of a daily newspaper regardless of size is of great morale value, as it gives the personnel contact with the outside world.

7. A good reference library should be provided.

(The generosity of the Special Services Section, Bureau of Naval Personnel, in providing excellent and abundant recreational equipment and supplies for Deep Freeze II was appreciated by all hands.)

Education

The education program at Little America consisted of five major parts: (1) Navy officer-type correspondence courses, (2) enlisted correspondence courses, (3) USAFI correspondence courses, (4) classes conducted at Little America, and (5) lectures at general camp meetings. The five portions combined were affectionally called the "University of Antarctica." Classes were formed in algebra, calculus, Spanish, Morse code, electronics, Bible study, and photography. Lectures were held nearly every week on IGY's and scientific and general interest subjects.

Recreational and educational programs will become increasingly important in future years as the antarctic operations become better established; and it is recommended that additional material be provided such as educational films, music-appreciation records, reference books, and recognized textbooks in many fields.

Religious Program

All materials of a religious nature were supplied by the Atlantic Fleet chaplain in Norfolk, Virginia, and the Destroyer Force chaplain in Newport, Rhode Island. Various special services items were procured from local purchase as well as military sources. The chaplain designated to winter over at Little America for Deep Freeze I was of the Protestant faith. Various personnel voluntarily conducted Rosary services for the Roman Catholic personnel.

During the off-loading operations at Little America, when personnel were working in two shifts around the clock, the chaplain conducted two identical services each Sunday in order that all personnel might have the opportunity of attending. Prior to the departure of the task force ships, a building had been set aside for religious and recreational activities. This building became more and more crowded with the breaking out and unpacking of recreational supplies. It was ultimately enlarged to permit one end to be used exclusively for religious activities.

The striking difference between a chaplain's duties in an isolated station, such as Little America, and the ships and stations normally assigned chaplains for duty, is that of population. A total of 73 men were served by the chaplain throughout the Deep Freeze I winter night. Considerable variation was experienced in the number of personnel attending worship services due to the varying work schedules. The musical program in connection with religious activities was very limited in that the field organ was affected by the coldness of the building floors and would not stay in tune. This made it necessary for the hymns to be sung a cappella during the regular worship services. Though this became a great source of enjoyment for those who attended, it is strongly recommended that chaplains assigned to duty of this nature be as proficient as possible in the musical arts.

In March 1957, a chapel was constructed and was dedicated as the Richard E. Byrd Memorial Chapel. Religious activities at Little America V during the wintering period of Deep Freeze II consisted of the following:

Protestant: Sunday morning divine worship services, Sunday evening Vesper services, Holy Communion services, choir, Bible study, and personal counselling and religious instruction.

Roman Catholic: Rosary devotional services led by a lay leader, and occasional visits by a Catholic chaplain to hear confessions and celebrate the Mass.

Participation in religious activities was greater than at the average military installation. For instance, during the wintering period of Deep Freeze II, attendance at Protestant services average 40 percent of all Protestant personnel at liberty to attend. This is at least double the usual percentage at the average military installation.

Byrd

Recreation

Inadequate space prevented full utilization of the recreation equipment, while erratic radio conditions proved detrimental to the successful use of the amateur radio. Although voice contact was poor, CW signals were moderately good. A few diligent ham operators in the U.S. made possible an unlimited traffic in hamgrams. This service was largely due to a civilian who brought down his own equipment and sent 700 of the 1050 hamgrams handled.

Movies were held nightly in the mess hall. The movie stories were representative in taste and mainly of a high standard. Reshowing was by popular request. The condition of the film, however, was often worn or damaged, while the identification was poor and required a complete inventory and remarking.

Jigsaws, model kits, leathercraft, and painting sets were popular, although a large amount of material remained unused. Card playing had its regular enthusiasts, mainly for cribbage and rummy. Poker enjoyed brief popularity, a fact no doubt influenced by the absence of money. The larger games such as pool, ping-pong, and basketball could only be played during the few weeks that space was available in the powerhouse. Climate unfortunately prevented use of the fishing gear. Bingo games were played intermittently during the winter night, but there was a lack of variety in the prizes available from the ship's store.

The hi-fi equipment used was a Rondine Jr Hi-Fi set with speaker and almost 400 LP recordings. Most records were of serious or classical music, and accordingly did not satisfy a large proportion of tastes. Instructions explained the care required for preservation of LP records and accounted for their comparatively good condition after one year's use. It was a nice debating point for the classic music lovers whether the small number of popular recordings received was an advantage or not.

Approximately 40 adventure books were received which, with a small number of paperback novels contributed by individuals, made up the station library. Most of the books purchased for Deep Freeze II did not arrive until the third tractor train in October 1957.

The shortage of beer limited the number of parties. The number of cans available for the winter night allowed a ration of 10 cans per man. These were sold in lots at the discretion of the officer-in-charge. The breakouts were on Saturday nights, prior to movies. On several other occasions, medicinal alcohol was similarly dispensed. Midwinter Day was a day of special holiday routine with a fancy dress competition, bingo, and a special menu which included a libation of medicinal alcohol. It proved a great boost to morale which had sunk with news of cancelled per diem and the depression associated with the long dark period in isolation. There is little doubt that the novelty effect of a generous ration of medicinal alcohol was an important factor. The only other party was the completion of the barracks recreation building, which occurred after the arrival of the third tractor train with a small supply of beer. This party enjoyed toasting and speech-making.

Education

The Byrd Station Education Office was established in April 1957 in a corner of the radio shack. The shelves and storage space were made from scientific instrument crates and what spare lumber that could be found. During the winter period, after most outside work had been completed, the crew began to take an interest in the Navy and USAFI courses. Both Navy and civilian personnel made extensive use of the textbooks for general reading and reference work. No classes were organized, for most personnel indicated they would rather work the courses individually.

At the end of the year, the officer-in-charge administered three college end-of-course tests and five GED tests. Two of the GED tests were on the college level. This was a high percentage for a group of only ten naval personnel.

The selection and quantity of USAFI texts and materials at Byrd Station were adequate. The selection of Navy courses were inadequate for such rates as ET, UT, and BU. The supply of Navy rating tests (servicewide) at Byrd was incomplete. One man became eligible to take the test for second-class petty officer three times, but no test was available for his rate.

South Pole

Morale

Important among the factors contributing to high morale during Deep Freeze II was the station itself. Compared with previous expeditions, the station was luxurious and was furnished with many of the comforts of home which were denied other groups. The living quarters were spacious, with no more than two men to a cubicle. This privacy tends to lessen the friction of men living in close quarters. The food was well prepared and had considerable variety. The welfare and recreation equipment, the library, and the movies (shown three nights weekly) made time pass quickly. The amateur radio was of prime importance as a morale item in allowing all to talk fairly regularly with families and friends.

It is also worth mentioning that in the small station there is always work for everyone every day. In this sense, the small base may have advantages over the larger base. Not only is there more work to do, but each man has a sense of being part of it all, instead of just functioning in his own capacity.

Morale is, to a large extent, dependent upon the quality of leadership displayed by the officer-in-charge and the scientific leader. At the Pole Station, the two managed the administration of the base with excellent judgment and set a fine example for the men by their own spirit of cooperation.

In the hope that improvements can be made, rather than in any spirit of criticism, the following comments are made. It must be realized that to men living in isolation, morale is vital for the success of the venture, and that morale is dependent to a large extent on outside news. It should further be realized that any dispatch received is scrutinized with a thoroughness unlike that of other duty stations simply because of the unique situation. During Deep Freeze II there was a great deal of bad feeling that arose from poorly worded dispatches or from administrative mixups. The most flagrant example of the latter was the antarctic per diem and the retroactive surcharge for meals. The men feel restless and uncertain when changes are made after their departure with so little hope of straightening out their affairs by radio. Dispatches should be written with the realization that each word is important, and that changes in procedure already established make the men lose faith in their superiors.

There was no instance of acute or chronic mental disorder in the South Pole personnel during the year. It cannot be denied that there were times of stress and personality clashes; however, occurrences were no more frequent than might be expected from eighteen healthy men confined so long in so small a station. Indeed, if anything, the South Pole Station had far less of this difficulty than predicted and must be considered an unusually smooth running group.

In the initial summer period, all hands worked extremely hard at the outside work trying to meet the sundown deadline in consolidating the base and completing the construction work. Some individuals tend to think they bear the brunt of the work, and this must be avoided by as even a distribution of unpleasant duty as possible. In general, however, this period during the summer goes smoothly, and the personnel sleep well and eat well.

During the twilight weeks, work shifts from community jobs to individual jobs and as such is a time of chaos and confusion. Such community work as still must be done is doled out, and each man simultaneously is checking his own equipment and making plans. This is the period when the men "settle in," and at this time there are apt to be conflicts over space and equipment. To avoid this, space assignments should be specific and a responsible individual should be in charge of group equipment. This is especially important with community property and recreational gear where there may not be enough items to go around evenly.

During the winter, the tendency is for the men to settle in routines. Boredom and monotony may be of concern unless every effort is made to add variety. This can be done by having weekly scientific and medical talks in the evenings, having contests and tournaments, having a different man make out the menu each week, and having frequent "holidays." ("Holiday" is a misnomer because most men will prefer to work at their usual rate rather than loaf. Nonetheless, sleeping late and having something a little special for supper makes these events worthwhile.) The most important time for all hands, to be sure, is the evening. With three movies a week and two lectures, most of the personnel will have their evenings well taken care of.

It should be noted that during the second half of the winter period, such personality conflicts as exist will probably become intensified. With the Deep Freeze II group, the best remedy was the group meeting — whatever that might be: movies, meals, discussions, etc.

The arrival of the first sign of twilight works magic on any morale problem. Even though it may be months until relief arrives, there is the feeling among most of the personnel that the year is over when the light returns, despite the fact that

the temperatures are the lowest of the year. The changes in activity, beginning to concentrate on outside work, and planning for the airdrops add zest to life; and the anticipation of mail, fresh food, and new faces adds excitement.

Welfare and Recreation

Recreation was limited during Deep Freeze I. There was a small library of pocketbooks, a commercial short-wave radio, and the galley to amuse the men. The pocketbooks were literally devoured. The radio was not too successful due to interference from our own communications. In the late evening many of the men liked to cook a bite to eat before going to bed. This was encouraged. Beer was available to all hands. Only one party was held, on the 23rd of December, prior to the evacuation of the Deep Freeze I group.

The welfare and recreation program during Deep Freeze II was generally satisfactory considering the circumstances. Recreational material for hobby crafts was abundant. Welfare and recreation credit sheets were maintained as directed. The sum allotted ($250) was found to be more than adequate considering the items available which were suitable for prizes.

There are, nonetheless, important improvements which might be made. First of all, it is useless to have a welfare and recreation fund if there is nothing to spend the money on. It is therefore recommended that the ship's store be provided with such gift and prize items as may seem appropriate. All such items should be clearly indicated on the Material Requirements lists to distinguish them from general sales items.

Hobbycrafts might be rearranged to de-emphasize the models and handicrafts and accent recreational photography. Even if our group was unusually photography-oriented, it is still felt that most groups in the isolated station will have a high proportion of enthusiasts. The recreational darkroom was in use almost constantly, and necessary limitations on the usage of photographic paper was an adverse morale factor.

Finally, it is felt that further provision for athletics should be made at the Pole Station. Because outdoor sports are never possible, winter or summer, and because of severe space limitations, the men seldom get a properly balanced schedule of exercise. Periods of very heavy labor are intermixed with periods of complete inactivity. Space should be (and is now) available for ping-pong, weight lifting, wrestling, and the like.

Education

The South Pole Station was well provided with educational materials of all sorts. Besides the USAFI courses, there were Navy correspondence courses and a large library of miscellaneous books provided by the IGY. In general, however, the men were quite casual in their approach to the educational program. For the most part, this was because each man had many more auxilliary duties than had been anticipated, and there was no time during the day for extra study. Some men completed courses toward advancement in rate, and several men, both Navy and IGY, used the USAFI reading material, but no courses were completed. Several foreign language classes were started, but none were carried all the way to the end. Because of the lack of expected large amounts of leisure time, the quantity of educational material far exceeded the demand for it. The most successful part of the educational program was a lecture series begun during the winter.

It is recommended that men do not take a large number of correspondence courses, but rather plan to concentrate on, and finish, two or three courses during the year.

Religious Program

The religious program at the Pole Station was initially hampered by the lack of proper equipment when most of the reading and Bible-study material failed to arrive. The items received were Bibles, choir records, and a few movies. Because of this, Sunday services were simple. They were held in the mess hall for a half to three quarters of an hour each Sunday evening. Following the service, there was an informal round-table discussion on some philosophical subject such as the significance of good will, the significance of tolerance, or the significance of love. One man would be assigned one of the topics a week in advance, and would present his views in a brief talk. The rest would then join in to give their own views. These sessions were very lively and served to break the monotony and routine of daily living in the isolated station. They are highly recommended for other groups.

Attendance at the Sunday programs ran in the 50 to 80 percent range all year with very little variation from one week to the next. Some of the absentees were on the night shift and might have attended under different circumstances. Communion, when held, would take place in the Jamesway annex, where there was more peace and quiet than in the mess hall.

It is felt that the religious program, despite its simplicity, was effective and appreciated by the regular congregation. The democratic technique of allowing all hands to participate in the services contributed to making the program acceptable to all faiths. The informality of the services did not appear to reduce the effectiveness of the services.

One of the problems encountered at the small station was the lack of adequate space for holding the services. The mess hall was used, but when such a building also houses the meteorological office and radio shack, it is far from ideal. With a mind to remedying this situation, a snow chapel was started at the 20-foot level in the snow mine. The area was planned as a single 15-foot by 20-foot room, with two 8-foot-radius domes above. Because available manpower had to be used in the glaciology mine, only one man could be spared for digging, and it is unlikely that the snow chapel will be finished for at least another year at the present rate. It is felt that, if completed, the space could be easily heated to 30 or 40 F on Sundays and might provide the quiet privacy which is so lacking around the base proper.

Hallett

Morale

The morale at this station had many high and low points during the operation and was dependent on many factors: meals, news, weather, and many other insignificant points. There were many instances of high and low morale for no apparent reason. As soon as aircraft flights were resumed, the morale went up with the hope of receiving mail and seeing some new faces. The loss of the motion picture projector also hindered the morale, but only until the men got used to doing other things with their spare time. The ham radio set was a great morale booster. It was the only contact with the outside world from March until November. In general, the morale at Hallett was good.

Recreation

Movies were a very good pastime. They were shown nightly and helped to pass the early evening hours. The movie projector furnished this station was a very old model, though it had been rebuilt. There were no spare parts furnished with it and no manual covering repairs. Only one spare sound lamp was furnished, and it was not the type for the projector. The projector was declared unrepairable after August 1957 and movies were not shown until early January when the USS ATKA made a projector available for use.

The hi-fi set was used by almost everyone. Classical music was not too well liked. The selection of popular music was somewhat limited. A varied collection of fiction and nonfiction books were available. All of the personnel spent some of their free time reading, and the variety of books provided allowed everyone to pick the subjects they enjoyed. A variety of games were available. Most individuals enjoyed playing pool and card games. Very few outdoor games were played because of the weather conditions. A ping-pong table was available but seldom used due to lack of space.

Parties were organized for birthdays and other incidents, but it was difficult to gather more than five individuals at one time. The most successful party was held on Christmas Eve, at which time there were 25 personnel living at the base.

Education

USAFI and Navy courses had been ordered by almost all of the men, but there was a lack of ambition rather than a lack of time to do these courses. The station scientific leader started teaching mathematics, but the classes did not last very long and were discontinued altogether with the arrival of the first ship.

Religious Program

Only five persons were of the Catholic faith, and they held services at least twice a month; more often during Lent and Advent. There was no Protestant lay leader at the station until November, after which some services were held.

Wilkes

Morale

The maintenance of high morale at a polar camp is primarily dependent on the careful selection of the members of the group. The few men who fitted in poorly with the group had an adverse effect on the whole camp.

Men should be given as much of an idea as possible as to what to expect and what is to be expected of them on this type of operation. It is felt that this would eliminate some misfits who would back out when they found out that the operation was going to be difficult and uncomfortable a large part of the time. Too few men had given thought to the fact that there was going to be a great deal of unpleasant work as well as interesting work on the operation. It is impossible to overestimate the importance of a sense of pride and loyalty resulting from friendly membership and effective participation in the affairs of a compatible, efficient group. Probably the commonest and most demanding hazard of living in isolated stations, particularly with members of varying backgrounds, positions, and jobs, as was the case during Deep Freeze II, is the loss of this feeling of group progress and belonging. Heavy emphasis on station improvement gave a feeling of accomplishment to the group and made the station progressively more pleasant to live in.

Recreation

The relatively liberal supply of recreational material contributed substantially to high morale. Though the equipment furnished was good, certain improvements could be made. The record collection was too esoteric for the musical taste of the group as a whole. The most popular records were light classics and well-established popular music. The taste of the scientists and officers differed considerably from that of the enlisted men once this middle ground had been covered, and tastes of the enlisted personnel were not very well covered, particularly in the field of western music. It would have been desirable to have two record players, even if they had to be of lower fidelity as a result.

The movie selection was felt to be low in quality, and there were a large number of duplicates and movies that had been seen on the trip down. This was unfortunate, as the movies were one of the key recreational items. The movies brought all the diverse elements of the camp together in the evenings for mutual relaxation, conversation, and kidding around. Much of the effectiveness was lost, however, when the movie list ran out and re-show schedules began, because many preferred to stay away. Particular care should be taken to assure that adequate projection equipment is provided. Two projectors, or at least one with adequate spare parts, should be provided. This would protect the prints and assure viewable movies all year.

The major possibility for outdoor recreation is skiing and considerable interest was shown in the sport; however, the skis furnished were too incomplete to be even jury-rigged into an acceptable outfit. Volleyball could be played during a large part of the year and was very popular for a time. The relief party had come prepared to try ice skating, and they should have a chance to try more of the other outdoor sports also. The equipment in the recreation building was heavily used. The miniature billiard table, the ping-pong table, and the shuffleboard were all popular. The only item of hobbycraft that got much use was the leathercraft; however, the materials received were criticized as being low in quality. Since hobbies are such a personal matter and there are so many from which to choose, it is believed that, rather than try to foretell what the demand will be for the group, it would be better to either let individuals supply their own or find out what the needs for a specific base are. Since quite a few men expressed dissatisfaction with the selection available in the library later in the year, it might be advisable to place a greater emphasis on books at the expense of hobbycraft. Card games, pool, ping-pong, shuffleboard, volley ball, darts, skiing, target shooting, and especially dog driving are good for those who participate. Probably the two greatest morale factors, however, were the ham radio and movies. The ham radio was used by everyone, and the ability to talk with friends and family did much to relieve the sense of isolation.

Education

The education actually accomplished was entirely in the form of Navy correspondence courses. The complete lack of correlation of the courses with the rates of the men for the bulk of the courses handicapped the program. It is recommended that the courses for both the next rate for which a man will be examined and the one above be ordered for all men of a wintering-over group. Many USAFI courses were checked out but none were completed. The materials furnished would have been adequate, however, to support almost any extent of interest had it existed. A course in mathematics was taught by one of the civilian scientists. There was quite a bit of interest, and the classes of one hour daily were attended by an average of four men.

Religious Program

The religious program at Wilkes consisted of Sunday evening services held twice a month. The services began with the call to worship and an opening prayer. This was followed by a reading from the Bible and the singing of a hymn. A brief sermon based on the Minister's Handbook followed, and the service was concluded with another hymn. Attendance averaged about four men per service.

Ellsworth

Morale

The morale at Ellsworth Station was very flexible and could seldom be described as excellent. The deterioration of morale actually commenced before arriving in Antarctica. While still enroute the spirits of the enlisted men took a downward turn when it was learned that their advancement in rate examinations were not on board the ship but were still in the post office in New York. The second blow to morale was received in a dispatch, about a month after the ships had departed the antarctic, stating that the per diem which most had received in good faith had to be refunded.

From the complaints of some of the men it was obvious that they were disillusioned with the antarctic and what they were doing there. The routine tasks and confinement of the station did not resemble the mental image of high adventure they had expected. Although this disappointment was generally felt by everyone, it affected only a few and the others made a good adjustment.

The primary and most important reasons for low morale at this station were attributed to the selection of personnel, and the organization and command structure as set up. There were a few civilian and military persons temperamentally unsuited to the duty and they harmfully influenced others. The organization at the station

was indefinite and changeable. Command presence and the wherewithal to back it up were absent. Lack of loyalty, cohesiveness, and polarization within the group were all factors adversely influencing morale.

Recreation

The sports equipment, games, and hobbycraft materials sent to the station were excellent in kind and amount. The following suggestions are made. Sports equipment such as baseball, football, basketball, horseshoes, and handball could be eliminated unless outdoor conditions make it possible to use them. Instead, more boxing, wrestling, and weight-lifting equipment could be included. The choice of ping-pong, pool, and shuffleboard tables should remain the same. In the hobbycrafts, smaller amounts of artists' painting supplies should be sent unless there are personnel who specifically order them.

It was considered best to ration the hobby supplies so that everyone had equal opportunity to share in them. In order to maintain a high interest in hobbies, only a few items were made available at one time. During the course of the year, however, all material was made available. It is recommended that one officer and an enlisted man be responsible for the welfare and recreation equipment and that it not be put out on a "help yourself" basis.

Moving pictures were the most popular recreational diversion. They were shown every evening and the attendance was usually good. There were a number of duplicates among the film titles.

Education

The interest shown in education was short-lived. Although almost everyone signed up for one or more USAFI or Naval training courses, very few were completed. No end-of-course tests were given. However, ten enlisted personnel took either high school or college GED tests. It is suggested that personnel going to the antarctic be dissuaded from ordering large numbers of educational courses as there is neither time nor interest on the part of most to complete them.

The civilian scientific personnel at the station gave a series of lectures on subjects in their fields. However, there was a very small attendance by Navy personnel.

Religious Program

Ellsworth Station did not have a chaplain, therefore regularly scheduled religious services were not observed.

SUBSISTENCE

General Comments

It is strongly recommended that at least one commissaryman who is well versed in menu preparation be assigned to each antarctic station. Deep Freeze I personnel at Little America were most fortunate in having a well-qualified menu planner; McMurdo was less fortunate, but satisfactory.

The procurement of provisions should provide for a normal diet, in quantities to provide for increased caloric intake. Foods should be selected to provide as much variety in menus as possible. The only limitation on variety is that storage facilities preclude any quantities of items that are damaged by freezing. "Even frozen foods suffer some quality deterioration during prolonged storage, particularly when not held at constant temperatures of 0 F or lower. Flavor changes occur more rapidly in certain frozen foods (chicken, pork, veal, etc.) than in others. Since a period of six to eight months' storage would elapse between processing and off-loading in Antarctica, a reasonable guarantee of eighteen to twenty months of life was necessary for food items furnished for the operations. Efforts to avoid risk of food loss through flavor deterioration included supplying the more perishable meats mentioned above in comparatively limited quantities for early consumption."[10]

All subsistence items and the quantities thereof were determined by and procured by the Navy Subsistence Office. Feeding during the wintering-over period presented no problems, except for the lack of variety of foods. Probably the biggest problem in feeding came during the summer season with the overcrowding of facilities. This was also the root of numerous other problems. When the population of camps built to support 90 and 70 people, as were McMurdo Sound and Little America respectively, are increased to 360 and 342 respectively, the entire organization (feeding, berthing, sanitation, transportation, etc.) suffers. This happened with regard to feeding. Neither McMurdo Sound nor Little America were designed for that many people, nor had plans envisioned logistic support for that number.

Storage of fresh frozen food presented varying degrees of difficulty at the individual bases during Deep Freeze II. Little America, Byrd, Pole, and Ellsworth Stations had no difficulty since temperatures were low enough all year to provide continuous freezing without mechanical refrigeration. The only requirement was keeping frozen items out of the direct rays of the sun and not covered by any material whose color or texture absorbed heat from the sun. At McMurdo, Hallett, and Wilkes Stations portable walk-in mechanical refrigerators were required because of the high outdoor temperatures. McMurdo did not have sufficient mechanical refrigerator space, and an attempt was made to bury the frozen provisions. A considerable quantity of food was lost as a result of the lack of proper refrigeration.

An interesting aspect of antarctic refrigeration is the possibility of storing foods at predetermined temperatures. By knowing the average annual temperature of a given region and the degree difference between the average high and low temperature, it is possible to determine the fixed temperature at varying depths of snow. At a depth of approximately 33 feet, the temperature of snow (ice) remains constant at the average annual temperature where sufficient statistical weather data is lacking. Below such depth the temperature remains constant or, if nearing sea water or earth, will rise. At depths of less than 33 feet the constant temperature varies on a regular curve up to slightly below the surface where sun heat penetration may adversely affect it. At Little America the average annual temperature is approximately -11 F; temperatures vary between -50 F and +30 F, resulting in a temperature variation of 80 degrees. On a graphic chart prepared by an IGY scientist, it was determined that a temperature of +10 F could be maintained at a 12-foot depth; a constant 0 F required storage at a depth of about 25 feet; at 33 feet, the temperature remained at -11 F.

McMurdo

After three days in which Deep Freeze I personnel at Hut Point ate emergency rations, a galley and a mess hall were set up in two adjacent 32-foot by 16-foot tents and meals were served regularly. The quality of the food was always good, but its quantity was often inadequate during the period of expansion in the camp's population. This inadequacy was eliminated as soon as a stable camp population was attained. On 23 January 1956 the mess hall was moved into one of the completed buildings, and on 16 February the permanent galley and mess hall were placed in operation. Excellent food, both as to quantity and quality was provided. Frozen vegetables, frozen meats, and frozen fruit juices were completely satisfactory substitutes for the fresh articles.

The meals prepared in the galley were of outstanding quality throughout Deep Freeze II. Visitors were always pleasantly surprised and base personnel were constantly appreciative of the excellent food served. During the wintering period, cake, pie, cookies, and sweet rolls were always available for coffee breaks and snacks between meal hours.

Foods which were especially liked included steaks and roasts, spaghetti, peas and corn, liver, pork, powdered grape juice, apple juice, lemon and orange juice, and canned fruits such as peaches, pears, strawberries, and grapefruit.

The diet was well balanced and supplemented by multivitamins, which were placed in the mess hall. Personnel were instructed as to their use and specific vitamins were given as needed. A few minor deficiencies in the Vitamin B complex

group and Vitamin C occurred in personnel with poor or irregular eating habits. These cases were given vitamin therapy as needed.

Meats and fresh vegetables were stored in refrigerators, insofar as possible, while bulk canned and dry items were stored outdoors and brought in as necessary. Food items which became unpalatable and developed an undesirable appearance during storage were Brookfield sausage, dill pickles, Deep Freeze I flour, roast, steak, and certain frozen vegetables. The Brookfield sausage, on cooking, was noted to be undesirable in taste and somewhat soggy, as were the dill pickles. Some Deep Freeze I flour became weeviled about August, but none was noted in the Deep Freeze II supply.

About 2500 pounds of roast, steak, and certain frozen vegetables, including asparagus, peas, broccoli, cauliflower, and corn spoiled about midwinter, because of heavy mold growth. These supplies were unloaded during a period when the temperature was above freezing and allowed to remain on sleds about three days. They were then stored in a poorly designed "ice cave," where they were covered with snow. Much of the snow melted during subsequent warm days. Proper drainage had not been established and many of the boxes containing these food stuffs became saturated.

It is believed that this accelerated or certainly allowed prolific mold growth. Mold has been noted to grow on walls outside and inside of buildings even in the heart of winter. The meat developed a particular tangy taste, which made it unpalatable, even on extensive cooking. The frozen vegetables developed an odor, which was quite nauseating.

By 1 August 1957 we were virtually out of steaks and roast. Unquestionably, these foodstuffs would have kept the entire year if refrigerator storage or proper drainage had been established. Deep Freeze III brought additional refrigerators and plans for a properly designed ice cave were discussed with the personnel concerned.

The Coman-Cutenko pemmican at McMurdo was unfit for human consumption. It was nauseating to taste and literally stunk. Heinz tomato juice layered out on standing during the winter. The taste was slightly altered, but the juice was usable. The Royal Crown Cola sold by ship's store in cans developed an undesirable taste and was not considered drinkable because of spoilage. Budweiser Beer did not layer out or develop a precipitate. Packages and cartons were, in general, satisfactory. Many cans were bent but very few were not usable. Most damage was noted to have occurred during off-loading operations.

Recommendations

1. Provide adequate refrigerotors for storoge of perishable items.

2. Provide replacement of present Coman Cutenko pemmican by more desiroble pemmican.

3. Allow such food as eggs, sondwich meat, pepperoni, shrimp, nuts, steak, roast, certain fruit juices (grope, lemon, orange, and apple) to be brought to Antarctica in greoter omounts.

4. Liver ond pork may be served all yeor if kept refrigerated.

5. Fresh vegetables, milk, and fruit should be on every aircraft flight possible from New Zealond.

6. Install better stoves and ovens at McMurdo.

7. Paper plotes ond utensils are desirable during crowded summer periods.

8. Provide closed water contoiners for drinking water in barracks, sick bay, and galley.

9. Provide an electric dishwasher and sterilizer.

Little America

The quality of food served to a group over a long period has considerable effect upon both physical and mental well-being. The high quality of the food served ot Little America during Deep Freeze I wos an important factor in maintoining high morale. Frozen fruits and vegetables, frozen eggs, fresh beef, pork, veal, poultry, frozen ond canned fruit juices were present on the tables throughout the entire year. The wide voriety of foods available ollowed the cooks to ovoid repetition of menus. In addition, the polotability of the mess was enhanced by the efforts of the cooks to provide delicacies which ordinarily would not be expected in the antorctic. Pizza, brandied sweet rolls, strawberry shortcake, and sauerbratten were some of the unexpected "extras" which made the men feel that Little America was the best feeder in the Navy.

Since the menus of Little America were consistent with what is considered a normal diet, nutrition was maintained at a high level. The fare was a high-calorie, high-protein diet with vitamin supplementation appearing in such items as fortified

flour, cocoa, and lemon beverage. There was no case of illness observed at Little America which could be attributed to dietary deficiency. In view of the adequate diet, it was not considered necessary for personnel to take supplemental vitamins. Vitamin capsules were placed on the tables in the mess hall and taken by the men as desired.

An "open refrigerator" policy was observed at Little America. Leftover foods were made available to the personnel for snacks. Raiding the ice box (for the midnight snack) was a common practice and a big factor in maintaining high morale, and also undoubtedly contributed to the midwinter weight gain of the majority of the personnel.

Trail parties using Sno-Cats, weasels, or heavy tractors operated at considerable distances from Little America V for periods of up to six weeks. The vehicles which were used had sufficient payload to allow provision of a diet similar to that at the main base. All trail operations during the spring of 1956 had a messing wanigan and a qualified cook. There was no need for concentrated trail rations, such as pemmican, other than as a stand-by emergency ration in aircraft survival kits, and as a safety factor for trail parties. Survival rations consisted of pemmican as compounded by Cutenko, which provides approximately 167 calories per ounce. The palatability of this ration leaves a good deal to be desired.

The diet, variety, and menu appeal available from subsistence items provided for Deep Freeze II was outstanding. Pleasing comments concerning the quality, taste, and variety were received during the summer. One difficulty encountered at that time was the large numbers of shipboard personnel who fabricated many kinds of excuses for needing to eat a meal at base messes. In June and July 1957 the complaints began. Lack of variety and sameness of meals were the most numerous complaints heard. Derisive remarks were also occasionally heard concerning the taste and quality. By November, eating became a chore to most wintering personnel and no interest in food was shown. At the same time, arriving summer personnel praised the food, as all had the previous summer. No complaints were made during the winter about missing fresh fruits, salads, eggs, milk, and vegetables. The impossibility of providing such items was readily accepted by all hands. Upon the return of the airplanes in October 1957 all personnel expected to be treated to large quantities of fresh foods. These were provided only in small intermittent quantities and in very limited variety. Because of this, numerous complaints were then received.

Temporary low-temperature freezer storage was provided by bulldozing a trench about 15 feet deep and placing frozen food in it. As the food was placed in the ditch it was covered by 6 to 8 feet of snow. At this depth the foods were maintained safely at a temperature of about +10 F at Little America. Later in the season the frozen foods were dug out and stored in the main provisions storerooms.

Some food items were received in domestic packs which were entirely inadequate to withstand the rough handling they received. The light, nonwater-resistant cartons disintegrated completely, necessitating picking out the individual cans from the deep snow in which they became buried. Because of the tendency to pilfer choice food items and the difficulty in maintaining intact banded pallet loads of small food containers, it is considered highly desirable to pack all subsistence in 62-cubic-foot waterproofed, banded boxes. The boxes should have built-in skids to enable handling by fork lifts.

It was also found that the necessity to package foods in other than glass containers is not critical. The desire to avoid glass containers resulted in nonprocurement of some highly desirable items. It is believed that the shape of the glass container and the extent to which it is filled are the controlling factors in breakage by freezing. With proper packaging, rough handling should be the only breakage factor. Glass-bottled products not provided for Deep Freeze II subsistence were later obtained from Little America III of 1940-1941. These items included honey, worchestershire sauce, tobasco sauce, hot sauce, English marmalade, A-1 steak sauce, and chutney. None of the glass containers were broken, although frozen, and had been subjected to temperatures as low as minus 80 F over a period of 17 years. All the items were delicious and used regularly in the Little America mess. It is of special interest to note that the "Land O' Lake" bottled and canned honey had not sugared in any instance.

During February 1957, after observing the keeping qualities of some of Scott's and Byrd's old provisions, inquiry was made to the Navy Subsistence Office whether any of such items were of research value. A reply outlining items and quantities desired was received and during October — November 1957, samples of as many items as practical were obtained from Little America III and IV and shipped to the United States. Samples of Captain Scott's provisions could not be obtained because of the loss of the helicopter.

Samples of milk powder were obtained from Little America III for use by the Atomic Energy Commission and the Department of Agriculture for help in establishing a base for zero world radiation which in turn will aid in determining the increase of radiation since the advent of nuclear explosions in 1945. Milk rapidly and easily absorbs radiation and it was desirable to obtain samples which had been packed and stored in a remote area before 1945.

An independent Air Force project at Little America was carried out to measure the amount of food eaten by personnel during different phases of the operation. Under different labor conditions, preliminary data indicated that there was little, if any, increase in food consumption over that normally consumed in a temperate

climate under similar work circumstances. Food consumption was considerably below requirements indicated in the U.S. Army Logistic Manual for Arctic Living and also the 5000 calories indicated as needed by the Navy Subsistence Office. "Navy Subsistence Office representatives, during the briefing lectures for commissary personnel and wintering-over personnel, explained that caloric needs would vary between individuals, according to their size, age, physical activity and length of time exposed to antarctic winds and freezing temperatures. The twelve-month stocks of food planned for shipment to Antarctica would provide an average of 5721 calories per man, per day. This is not an indication that actual consumption was expected to be this high, rather that supplies allowed generous "insurance" that quantities would meet maximum food needs."[10]

The following comments are made concerning specific items of subsistence provided for Deep Freeze II:

Navy Beef and Gravy	Poor taste and too little gravy.
Corned Beef	Personnel did not like.
Fresh Frozen Rib of Beef	Too much fat.
Dry Whipping Cream	Made up too lumpy.
Peanut Butter	Too dry, not best taste. Peter Pan DF I brand was far superior.
Apple Jelly	Personnel did not like.
Fresh Frozen Eggs	30-pound can was too large for 100-man crew and far too large for smaller group; considerable waste.
Fresh Frozen Asparagus	Too tough and too much of stem included. Tips only would be more desirable.
Canned Bacon	Too salty.
Chicken Fowl	Too fatty, tough, and personnel did not like.
Instant Milk, Foremost	Outstanding for all uses, and best for drinking.

Pork and Beans	Excellent, greater quantities needed.
Popcorn	Well liked but considerably greater quantity needed.

The following items are considered to be highly desirable as food items that should be provided. Many of these items were used at Little America V from supplies found at Little America III (1940) and IV (1947) and Captain Scott's Cape Evans Camp (1911), and all were found to be excellent. Other items in the list, even if not of best keeping ability, would add considerable variety to the menus to the extent available and usable.

Assorted cold cuts	Dehydrated cabbage
Assorted cheeses	Assorted table sauces
Canned juices in individual sized cans	Salad dressing
Pepperoni	Tomato paste
Liverwurst	Tomato puree
Shrimp, wet-pack	Cake mixes
Chicken fryers, cut up	Sweet cherries
Canned ham	Canned maple syrup
Sardines, canned	Fresh frozen scallops
Salmon, canned	Food coloring
Fresh frozen fish	Fresh frozen corn on the cob
Breaded shrimp	Ready made hamburger patties

Byrd

Food plays a very important role in life at an isolated cold-climate base. Its preparation is as important as its variety, although beyond a few months it was felt variety assumes precedence. This may also be expressed as the quality of the food and the skill of the cook. The cook was skilled and conscientious but he was

handicapped in the galley equipment. Many important items were either inadequately supplied or not supplied at all. Since this included many of the flavoring agents, both preparation and variety were affected.

Expression of dislike as well as actual dislike was greatly influenced by the social background of the individual. The more "socialized" persons who had some experience of exotic dishes tolerated the ordinary fare and enjoyed the unusual. For the less "socialized," complaint was less well suppressed, while prejudice deprived many from trying unusual items, shrimp being a good example.

All provisions remained at ambient outside temperatures in a parachute-covered shelter at the rear of the galley. The extreme cold in which all foodstuffs were stored necessitated a breakout at least twelve hours prior to intended use. Items such as canned tomatoes, catsup, spices, garlic, vinegar, olive oil, corn starch, shrimp, and cheese either failed to arrive or else were inadequately supplied. Variety of diet was curtailed accordingly and became monotonous for the latter half of the year. Despite this, complaints were few, which reflects on the cook's ingenuity. An acetic acid solution obtained from the sick bay provided a vinegar substitute for salads of canned vegetables and macaroni.

Beef was supplied in abundance and provided the mainstay of the protein fraction of the diet, especially in the three-month period before resupply. The roast beef was of fair quality with much central fat. Ground beef was excellent. Beef stew with gravy was unpalatable and unpopular. Liver showed signs of spoilage three months past the expected date, while prepared hamburgers were of good quality throughout the year. Well-cooked frying chickens were edible until stocks were exhausted in August 1957, four months past their expiration date. Stewing chickens remained tough and unappetizing despite thorough cooking.

Vegetables, both fresh-frozen and canned, were of good quality. Powdered milk was excellent. "Brown Swiss" cocoa became exceedingly popular. Some small amounts of the butter contained dirt. Ice cream varied in taste and texture due to the uncontrollable and inconstant rate of cooling when placed in the food shelter. The mix sometimes decanted out of solution causing the contained water to freeze in a layer on top. Pies were made using flour and sugar for thickening which was satisfactory except for a slight "flour taste."

South Pole

Basic provisions were provided for two years, with the second or reserve year's provisions being entirely canned or dehydrated. Both years' stocks were heavy on basic staples with a minimum of so-called luxury items. Quantities of certain items

were sufficient for three years at existing usage rates and it was recommended that additional quantities of these items not be delivered for Deep Freeze III.

Food preparation was excellent, due to the outstanding efforts of the cook. The impact of food upon morale cannot be over emphasized. The quantity and variety of so-called luxury items should be greatly increased, and should be sufficient to provide one special meal each week. Such a meal is invaluable both as a morale factor and as a break in routine which greatly aids in dispelling monotony.

No spoilage was noted in any foods. Summer temperatures have not exceeded +6 F. Because of the exceptionally cold conditions, frozen foods normally considered perishable can be, and have been, kept indefinitely. Quantities of these items should be greatly increased.

Food likes and dislikes was a matter of some importance at the South Pole Station because of the apparent weight loss among the personnel. The only item in our ration which was universally unacceptable was the canned hamburger. The bulk of the diet (i.e., meats, potatoes, vegetables) was received well throughout the year, due perhaps to two main factors. The station was fortunate in having an excellent cook whose quiet, persistent devotion to his work resulted in consistently good meals. To add variety to the menu the policy of having a different man make up the menu each week was adopted. Many of the standard items which could so readily have become tiresome appeared on the tables in exotic and tempting disguises. Although this policy resulted in periodic failures, the broadened menu system was important in adding zest and interest to the diet.

Of the accessories and delicacies much could be written. The occasional serving of shrimp or turkey was universally acclaimed. This is best seen in the dessert line of foods; and once again, having a good pastry cook is important in providing the cakes, pies, and cookies which are such a morale factor. Movie time was usually a time for snacks, cookies, pie, and so forth; but otherwise, there was little eating between meals. Coffee breaks in afternoon and morning were a matter of habit for about half the group. It is interesting to note that, during the summer when hard outside work was being done, cocoa was by far the most popular drink. As winter came, however, and outside work was completed, coffee superseded cocoa almost entirely.

Hot drinks, exclusive of coffee, and soups were not in as great a favor as might have been predicted. Iced tea was consumed in great quantities with almost every meal, along with iced water. ice cream was a favorite for movie nights, but had to be brought inside at least three or four hours before mealtime to thaw out.

Bottles of vitamins were available at all times on the mess hall tables but were taken regularly by but a few. There were several men who flatly refused to take vitamins at all, and this group showed no ill effects or avitaminosis during our stay. This speaks highly for the diet and food issued. There was no instance of craving for vitamins; and although mention was sometimes made how wonderful it would be to have a fresh egg or a piece of lettuce or some fresh fruit, there was surprisingly little grumbling about the rations. The food was of sufficient variety, well packed, and well prepared.

The so-called luxury items should be stressed wherever feasible. If there is extra expense involved, this is amply offset by their double function as not only food but also a morale booster. If even one meal of lobster meat or some other "extravagance" is included in the menu, it is used as a celebration. Although it may appear as an unimportant trifle, it is welcomed enthusiastically as a break in the monotony.

A small quantity of good liqueurs and wines would be highly desirable for special occasions. It is felt that a relatively small quantity of good alcoholic beverages would be much better from all standpoints than the large quantities of poor-quality medicinal alcohol.

Comments on specific Deep Freeze II items:

Fresh frozen pork, cut-up chicken, whole turkeys, etc.: increase quantity of each. Fresh frozen vegetables: increase quantity to a full year's supply, especially peas and corn. Fresh frozen vegetables: greatly preferred over canned varieties. Beef, roast and steak: too much low-quality meat in these items. Ground beef, prime roast, and sirloin or tenderloin steaks: proportion should be greatly increased. Frozen eggs: excellent in all respects. Dehydrated diced potatoes: found quite satisfactory in making potato salads. Turkey roll: excellent, increase in quantity highly recommended. Cheese: well liked, but a variety of cheeses should be provided rather than just one kind. Shrimp: canned veined shrimp greatly preferred over dehydrated jumbo variety. Fresh frozen juices: quantities provided were totally insufficient.

Recommendations for new items:

Soft drinks should be provided for nondrinkers; none were provided for Deep Freeze II. Lamb is highly desirable as a menu variation. Fish is also highly desirable for an occasional change. Ingredients and flavorings for various types of sauces and dressings should be provided.

Hallett

A temporary galley and mess hall was provided in a double Jamesway hut pending the completion of the permanent mess hall building. During the period of construction, three meals per day were served. When the main mess hall was completed the temporary mess hall was converted to a recreation area. After the departure of the construction crew, and because of the varied hours of the scientific and operations personnel, it was decided that the breakfast menu would be discontinued and personnel would serve themselves a brunch-style meal. The noon and evening meals continued to be prepared in the normal manner.

It was found that an individual's likes and dislikes varied with his social background. An example is the case of the New Zealanders who were not used to highly seasoned food and complained about the frequent use of ground beef and chili. Variety in the meals was lacking, and the situation became worse due to the early use of pork, veal, and liver. This left beef as the only frozen meat. The following items are listed with their usage and comments:

1. Pork was used until August 1957 at which time it was getting rancid.

2. Frozen frankfurters lost their taste and were seldom used.

3. Chicken friers were used all year; at the end of 1957 they had some rancid taste and smell.

4. Calf liver was used very early in the year; no change was detected.

5. Rabbit had a rancid smell and taste and was all used by May 1957.

6. Boneless turkey was saved until Thanksgiving Day. It had lost some of its taste and the fat was getting rancid.

7. Young tom turkey was all used early in the year and no change was detected.

8. Stewing chickens were used early in the year. They were fat and got rancid very early.

9. Canned frozen hams were kept until the end of the year and were in excellent condition.

10. Canned frozen citrus juices kept well until the reefer temperature rose early in December, at which time they had to be used because they had started to ferment

11. Frozen vegetables kept very well throughout the year.

12. Canned beef with gravy developed a metallic taste and was seldom used.

The general diet was considered by most to be monotonous. The only fish meals available were canned tuna fish and six cans of shrimp. Beef, in general, was well liked; its taste was always good and it was prepared in many different ways. Pork was well liked but was used up early. Canned ham was well liked but was used as a delicacy because of the short supply. Poultry in general was not well liked. Variety in its preparation would have made it a better choice. Veal was well liked, but again there was a short supply. Bacon and sausage links were liked and used throughout the year, mostly as a breakfast item. Luncheon meats and corned beef were mostly used as snack items. Rabbit was not too popular and was all used early in the year. It is believed that frozen fish would have been a popular item. Canned vegetables were well liked. The powdered potatoes were served mashed, which was not very popular. The diced potatoes were served plain after boiling. Foremost instant milk was well liked by all hands. Spices were abundant and were used mostly in the seasoning of meats. Desserts consisted mostly of canned fruits, jello, and ice cream. Cake or pie was generally served once a week.

To increase the variety of the diet it was suggested that Deep Freeze III bring frozen fish, fresh eggs, frozen french fried potatoes, a variety of frozen vegetables, and other items.

Wilkes

The general reaction to the food was that it was adequate but monotonous. A few items were generally thought too low in quality to be acceptable. The guide furnished as to usage dates was not as helpful as more specific information on what foods were expected to deteriorate and when. The quantities of foods furnished were such as to make compliance with the guide impossible. As an example, all of the pork furnished would have had to have been used in the first two weeks of station operation.

The frozen beef was the mainstay of the diet all winter long and was in general well liked. Deterioration was most apparent in the steaks. The change was never great enough to warrant discontinuance. In view of the fact that some of the other

meat maintained its flavor considerably longer than was expected, it is felt that the percentage of beef in the diet could probably be reduced and the "hamburger again" type of reaction considerably reduced.

The popularity of the pork was less than that of the beef, and there seemed to be a few men with a general dislike for pork. It was in general these men who objected first to the flavor change in the pork. The pork loins began to seem coarser and drier by May 1957. By June the change was noticed enough that the use of the loins was discontinued except in ground form. The supply became exhausted by late August. The canned frozen hams were served quite frequently early in the year, and their popularity seemed to suffer somewhat from this. One ham was kept out for use at Thanksgiving as a test and was quite good when served then. The canned ham chunks were served barbecued and as ground meat. The meat was well received barbecued but was not satisfactory as ground meat unless mixed with pork. A larger number of the whole canned hams would have improved the menu. Smoked and cured meats would have been very popular and would seem to be ideal for long storage.

Poultry was generally average in popularity but a higher percentage of roasting birds would have been desirable. Both the rolled boneless turkey and the roasting birds were very popular. They also resisted deterioration better than expected. The chicken fryers were used until early December 1957 without objectionable flavor deterioration. An increase in the dryness of the meat occurred during the last two months, but this was not marked enough to render the meat unpalatable. The amount of frying chickens was greater than the popularity warranted. Stewing hens were popular in a number of variations, and an adequate supply was furnished. They were used all year with only a slight dryness noticed. The veal was well liked, and a larger supply would have been an improvement. It was used until late November 1957 with no apparent deterioration.

The sea food could have afforded much more variety in the diet if a better selection had been available. The canned salmon was low in quality but could have been used about three times as much in spite of this. The dehydrated shrimp was good and could have been served more frequently. The canned tuna was satisfactory and furnished in the desired quantity. Any other additions of sea food of reasonable quality would have been helpful in varying the diet. Except for fresh fruits and vegetables, no one category of food was more craved than fresh fish, lobsters, or oysters.

The rabbit was not very popular, but it is felt that this was partly because it was served too frequently in an effort to use up the supply before the flavor deteriorated. Use was discontinued late in May when a stronger flavor was noticeable.

The bacon, canned sausage links, and canned luncheon meat were served as breakfast meat. The bacon was not too high in quality but was the most popular of the three. The canned sausage was universally disliked. A marked flavor change was noticed in the frozen frankfurters late in May, and their use was discontinued then. The calves liver was served until 12 June 1957 without deterioration but was surveyed before the next usage, when the medical examination disclosed some possibility of spoilage.

The canned peas, corn, green beans, spinach, carrots, beets, lima beans, and the frozen broccoli were the staple of the vegetable diet and were of about equal popularity. The canned tomatoes and creamed corn were not of very good quality and suffered in popularity. The frozen collard greens were very coarse in texture and almost tasteless when first used. The frozen cauliflower seemed to suffer a loss of flavor during September. This was not found seriously objectionable, and the use was continued through January 1958 without further deterioration. The frozen lima beans were fairly good, but the frozen asparagus was very tough and not well liked. The dried vegetables were adequate in all respects, and the amount of variety that could be achieved with the dried potatoes was quite good. The frozen mixed vegetables were not liked and could have been replaced with chop suey vegetables to good advantage.

Desserts seemed to be basically less in demand than usual. The lack of a satisfactory solution to the problem of making ice cream from the machine-type mix cut out a great number of possible variations in the dessert menu. An ice-cream mixer would have been a valuable addition to the galley. The canned fruits were of good quality. The frozen strawberries were markedly too sweet and were not even of average popularity as a result. The rest of the frozen fruits were satisfactory, with the rhubarb being especially good. The gelatine dessert was a good variant and fairly well liked. The prepared pudding mixes were most popular when used as pie filling.

Beverages were generally better than expected. The Foremost Dairies dried milk was particularly good. The instant cocoa was satisfactory and fairly popular. The tea, coffee, and instant coffee were all satisfactory. The frozen grape and citrus juices were very good. Neither the canned nor the dehydrated juices were comparable to the frozen. The canned citrus fruits developed an acid taste early in June. Some people did not mind this, and the juice was used until November. The canned grapefruit segments did not suffer this effect. A larger supply of some frozen fruit juices, which ran out in midyear, notably apple and grape, would have been appreciated, largely because of their utility in Saturday evening punch. Popcorn was very popular for weekend movie parties, but in spite of contributions from private stocks of two individuals, it ran out early.

The assortment of spices and sauces was fairly complete. There were some rather useful items missing. For example, worchestershire sauce and soy sauce would have allowed use of quite a few additional dishes, while a variety of meat sauces would have added to palatability.

A few unconventional items were tried in order to introduce additional variety into the menu. Penquin eggs and seal meat were tried on an experimental basis and would be of great use under survival conditions. When given the choice, however, the group preferred the conventional diet. Some recipes not in the Navy card file were used with success. A ground beef pie using the meat mixed with corn and carrots and topped with whipped potatoes was about average in popularity. A pie with graham cracker crust and vanilla cream filling topped with meringue was very popular. Hamburgers were made using the meat with no fillers at all and these were much better liked than any of the other types of hamburgers.

Multiple vitamin capsules were available on mess hall tables at all times and during the year approximately 5500 capsules were used. However, some men did not take vitamins and yet continued to be quite healthy and energetic, giving testimony to the nutritional adequacy of the food supplies.

The two 675-cubic-foot walk-in type refrigerators worked well most of the year. They required regular defrosting in order to keep the boxes cold. Toward the end of the year, however, a great deal of trouble was experienced in keeping the boxes cold enough; and they required almost constant attention. It is considered that this was probably because no one at the station had had any training or experience with refrigerators of this type. A third unit was kept in reserve and used when one of the others could not be repaired.

In general the packaging was satisfactory. The cartons in which the Campbells soup cans were packed were unbanded and came apart from being water-soaked in outdoor storage. The individual packs of dry cereals became wet during storage and were somewhat soggy as a result.

<u>Ellsworth</u>

The quality and quantity of foodstuffs received were excellent; however, improvement could be made in the variety of foods. As many as 280 at a meal were fed during construction. Most comments and reactions towards meals served during the wintering-over period were favorable. Some items were more desired than others; namely beef, ham, veal, and liver, more than rabbit, pork, and chicken. The latter items, however, had an appreciable demand. Special items

were well received and used chiefly for birthday parties, snacks, and quick lunches. Instant dry whole milk was the favorite beverage. Hot pastries and pie alamode were the favorite desserts.

The packages and containers were very practical for this type of operation. The only damage sustained was from the hooks used by cargo handlers.

It is believed that some items could be stored longer than is generally recommended. At no time did our perishable provisions experience temperatures above freezing. As soon as they were off-loaded from the cargo ship, the fresh-frozen provisions were placed in a trench approximately 3 feet deep and covered with 3 feet of snow. They remained in this place of storage until the weather was cold enough for storage in the provisions tunnel. All fresh-frozen provisions remained in this storage tunnel until August 1957, at which time we constructed a cold-storage pit, a small room set 30 feet away from the provision tunnel, and 20 feet below the snow surface. A smaller tunnel connected this storage space with the main storage tunnel. The temperature in this cold-storage pit never exceeded 0 F.

Sausage, frankfurters, and pepperoni became unpalatable and undesirable after prolonged storage. This condition, first noticed during February 1957, was evidenced by an undesirable color, slight growth of mold, and quite a strong flavor. These items were discarded as unfit for use. Some deterioration of flavor was noted in the fresh-frozen chicken fryers and stewers due to prolonged storage, but they were still in use when we were relieved by Deep Freeze III wintering-over personnel. Of the more perishable items, pork loins were received in excellent condition and remained good until completely used in the mess during July 1957. Semiboneless veal was excellent and remained good until completely used in the mess during July 1957. Canned whole perishable ham was excellent and remained good throughout the year. Our last meal of ham was Christmas 1957. Eviscerated and boneless rolled turkey was received in excellent condition and remained good throughout the year. The last meal of turkey was served Thanksgiving 1957.

Food of questionable quality was examined by the medical officer before being prepared for consumption. Weekly menus were checked for caloric value, for the proportion of protein, carbohydrates and fat, for vitamin and mineral content, and for palatableness before submission for publication. Decavitamins were distributed to all personnel to supplement the daily vitamin intake. Cooks and mess cooks were inspected for personal cleanliness and freedom from disease. The galley and its utensils and the methods used for cleaning were inspected daily.

Items that were unpopular from an overall standpoint were:

Hamburgers, canned with gravy

Beef chunk, canned with gravy

Sausage, pork link, canned

Special or unusual items that would be welcomed for future polar operations are:

Flours, canned, graham, rye, soft wheat

Sauces, worcestershire, steak sauce, soy sauce, chutney

Flavorings, banana, walnut, vanilla, maple, etc.

Honey

Juices, canned, mixed vegetable, prune, apple, etc.

Potatoes, white, canned whole

Cabbage, dehydrated, shreaded

Egg whites, dehydrated, powdered

Assorted cheese and meat spreads

Chocolate chips, sweet and bittersweet

CLOTHING

General Comments

A happy medium should be struck between the amounts and types of clothing which Deep Freeze I and Deep Freeze II personnel were issued. Deep Freeze I was a little too austere, whereas Deep Freeze II had numerous items of clothing for research purposes.

It is difficult to determine the best type of clothing to wear, because in many instances a particular job requires particular clothing. Types of clothing worn differ with different locations in the antarctic. General principles that should be considered in the design, procurement, and wearing of antarctic clothing are warmth, comfort and usefulness, practicability, availability, and color. Bright colors should be worn when flying or when working outdoors. This enables one to be spotted easily if lost and enables one to see members of his own party quickly and easily when doing dangerous work.

It is believed that clothing procured from the Army is more suitable for antarctic conditions ashore than that presently in Navy stocks. More light clothing, such as the CB utility greens and field shoes should be issued each man. This type of clothing, with the long waffle-weave underwear, was worn more often during Deep Freeze I than the heavy cold-weather clothing. A-2 clothing is satisfactory, but the A-1 clothing should be completely eliminated. Most personnel resorted to the extreme cold-weather clothing only when their lighter clothing was completely worn out. "The men did not like heavy clothing. They used the heavy underwear, heavy Army OD khakis, light jacket, and thermal boots. The A-1 gear was too bulky for summer but was needed in the winter. The cushion-pad socks were good. More underwear and OD khakis were needed."[7]

Each individual soon finds what combination of clothing is most comfortable for him, and it seems impossible to get a majority of any group to agree what is the best type of clothing for antarctic wear. It is considered that if the items of clothing listed in Table III were issued to each man he could find his own best combination.

McMurdo

The cold-weather clothing provided for Operation Deep Freeze I was standard Navy issue A-1 and A-2 clothing. In addition, there were limited quantities of aviators' flight clothing. In general, the clothing was adequate, though the supply was short and the loss from wear was great. No single combination of garments can be said to be best for antarctic wear because there is a wide variation in individual requirements for protection and a wide variation in individual preferences.

Handwear

Next to the face and ears, the fingers are the parts of the body most subject to frostbite. It was noticed that some people were more susceptable to this than others. Personnel suffering from any form of arthritis or skin grafts will readily experience frostbite sooner than those who do not. Personnel who wore inadequate amounts of clothing on their hands often experienced severe pain and throbbing as they worked, and in a few instances had to be brought to a sick bay or returned to camp.

Table III. Recommended Clothing Allowance for McMurdo (A) and Little America (B)

ITEM DESCRIPTION	QUANTITY					
	Winter				Summer	
	Inside		Outside			
Headwear	(A)	(B)	(A)	(B)	(A)	(B)
Cap, field, cotton poplin	2	2	2	2	1	1
Hood, winter	1	1	1	1	1	1
Upper Body Wear						
Undershirt, waffle-weave	5	4	5	4	2	2
Shirt, wool, 16-oz OG	2	2	2	4	2	2
Shirt, cotton khaki	6	6	4	4	2	2
Coat, cotton sateen	1	1	3	2	1	1
Liner, coat, natural mohair	1	1	2	2	1	1
Sweater, wool, button style	1	1	1	1	1	1
Lower Body Wear						
Underdrawers, waffle-weave	5	4	5	4	2	2
Trousers, wool-serge	2	2	2	2	2	2
Trousers, cotton khaki	4	4	2	2	2	2
Trousers, cotton sateen	2	2	4	4	2	2
Liner, trouser, field	1	1	2	2	1	1
Handwear						
Glove, shell, leather	2	4	4	6	2	4
Glove, insert, wool, knitted	2	4	2	4	2	3
Gloves, cloth, leather palm	2	2	4	4	2	2
Mittens, arctic, cotton, Oxford gauntlet	1	1	3	2	1	1

Table III. Recommended Clothing Allowance for McMurdo (A) and Little America (B) (Cont'd)

ITEM DESCRIPTION	QUANTITY					
	Winter				Summer	
	Inside		Outside			
Footwear	(A)	(B)	(A)	(B)	(A)	(B)
Boot, combat, white thermal	1	1	2	2	1	0
Boot, combat, felt	1	1	1	1	0	1
Boot, mukluk, cotton duck with rubber sole	0	1	1	1	0	1
Shoe, high-topped	2	2	3	3	2	2
Slippers, wool-lined	1	2	1	1	1	1
Socks, wool, OD, cushion-sole	8	10	8	10	4	6
Socks, wool, natural	3	3	4	4	2	2
Socks, wool, white felt	0	2	1	2	0	1
Insole, felt	2	4	4	4	0	2
Miscellaneous						
Bag, duffle, canvas	2	3	2	3	2	2
Belt, web, khaki, with buckle	2	2	2	2	1	1
Muffler, wool	1	1	1	2	1	1
Sunglasses (B&L), with nonmetal attachments	1	1	1	1	1	1
Sunglasses, plastic	2	4	4	6	2	3
Goggles, aviator	1	2	1	2	0	1
Face mask	0	0	1	0	0	0
Sleeping bag, double	0	1	0	1	1	1

The greatest deficiency for Deep Freeze I was in hand covering. Heavy gloves and gauntlets kept the hands satisfactorily warm during exposure to the cold, but when these were removed for a job requiring manual dexterity, the hands were exposed. No satisfactory glove was available during Deep Freeze I which would provide both warmth and dexterity. For those people, who require dexterity and who will remain outdoors for long periods of time, a contact glove inside a woolen mitten may or may not be worn inside the large arctic mitten.

The arctic mitten is very good protection against the cold and is the only adequate protection for long periods. To avoid losing the large mitten while working or traveling, the mittens should be connected by a strap over the shoulder. Such mittens may be removed for short periods if finger dexterity is required.

The leather gloves with fingered wool liners were very satisfactory for mild cold and short periods of outdoor work. They were the most popular glove, except in severe cold, for they allowed dexterity of fingers, in contrast with the other hand gear. They readily wore out and were easily lost or misplaced. Since only two pairs were issued per man, the supply was soon exhausted.

The leather mitten without fingers was also used, but was not as satisfactory as the glove because of limitation of manual dexterity. Another glove used for moderately long periods of outdoor and moderately cold weather, was the lighter but similar variation of the arctic mitten, in which the index fingers and thumb were movable.

Contact gloves were often worn, particularly by flying personnel. In a helicopter crash contact gloves undoubtedly saved personnel from more severe burns of the hands than those who did not have them. The nylon or cotton of which they are made is not fireproof and does burn, but protection offered by them is certainly better than none at all. The woolen mittens with fingers may also be worn inside standard aviation gloves.

Footwear

The types of foot gear at McMurdo for Deep Freeze II included fur-lined bedroom slippers, private dress shoes, boondockers, rubber overshoes, felt bunny boots, white thermal boots, black thermal boots, mukluks, ski boots, skis, and ice crampons.

Indoors, boondockers were ideal wear in the summer and winter. Cushion-soled, brown woolen socks were ideal for wear in these shoes. Fur-lined house shoes are ideal indoors; they should be high-topped and individually fitted. The house shoes sent down with Deep Freeze III were excellent, but the slippers sent with Deep Freeze II were very poor.

Thermal boots were satisfactory for outside use on snow surfaces and on cold days on bare areas of ground, but were too warm for use on these areas on sunny days when ground temperatures were above freezing. On sunny days, ski mountain boots or regular work shoes covered with arctic overshoes provided a more satisfactory work boot. Though some found that the constant dampness of the thermal boots softened the skin and made the boots unwearable, most personnel found their feet remained in good condition. The black thermal boot was less preferred to the white thermal boot, even though it is lighter. A few personnel obtained frostbite from wearing it. It does not adhere as well on slippery, icy terrain as the white boot. The poor fitting of the thermal boot is the greatest contributing factor to feet exhaustion on any of the long hiking or sledging trips. Another factor is that the thermal boot does not give much support to the arch of the foot. General complaints of chaffing were eliminated by providing a boot of the proper size.

For outdoor wear in the thawing season, rubber overshoes were necessary over the boondockers. An excellent medium cold-weather shoe was the felt bunny boot worn with one pair of cushion-soled socks and one pair of heavy, white, high-topped woolen socks. Some people wore these about camp in midwinter and were quite comfortable. Many wore the rubber-soled mukluk throughout the winter but no one would wear the white canvas mukluk. The ski boot was worn in weather similar to that of the boondocker. It adheres and grips better to slippery surfaces than the boondocker and is also warmer. Ice crampons would probably be useful for mountain climbing, but otherwise their usefulness was limited to that of being an emergency item.

Socks

In general, the types of socks worn at McMurdo were very satisfactory. Two types were used. They were the brown cushion-soled socks and the extremely heavy high-topped white socks. The brown socks were worn most of the year, in the boondocker or in the thermal boot. The white sock was worn over the brown sock in the felt bunny boot and in the black thermal boot.

Head, Face, and Neck Wear

In general, a light billed cap with earflaps or a fur-lined cap with fur flappers was used during the summer and winter, covered by the removable fur-lined parka when necessary. Blue stocking caps covered with parkas were worn by a few. The Air Force parka covers the face, extending out, leaving only angular slits for the eyes and is ideal for windy storms. Beards were worn by most personnel and the protection given was noticeable; however, beards increased the contamination of face burns on the patients of a helicopter accident. Face masks were worn by a few

persons. Woolen muffler scarfs kept snow from getting down one's neck and doubled as a face mask when necessary. Parachute silk was used to make some scarfs and provided color to apparel.

Sunglasses

Sunglasses of the plastic type are practical and adequate for outdoor work; the Bausch and Lomb glasses are ideal, except that the metal attachments readily freeze to the face. Goggles were effective and were used when out in severe blowing snow to protect the eyes. "There were not enough sunglasses; everyone should have several pairs. In December and January, sunglasses are a must out of doors. Snow blindness is no joke. Sunglasses with metal rims freeze on your face. Aviation goggles fog up and some types scratch very easily."[7]

Underwear

The Navy waffle-weave underwear was the most popular. The Army-type underwear, which is made of worsted wool, scratched and was worn by very few persons. "Sweat suits" were used by a few and were found to be satisfactory.

General Requirements

Basically, for indoor work a light shirt can be worn, such as the Seabee green or standard khaki material or a moderately heavy worsted-wool shirt. Cotton worsted-wool serge trousers, if not too heavy, may also be worn comfortably. Most of the time, if one wears waffle-weave underwear, he prefers a light shirt and trousers indoors; if regular skivvies are worn, he prefers the heavier wool shirt and trousers mentioned above. Personnel who do not go outside very often may then put on coats and parka with proper foot gear as needed to walk between buildings.

Outdoor workers used many types of clothing, some of which were satisfactory, some of which were not. A general rule worth mentioning is that clothing should be adequate for the type of work to be done, and removed as needed when the wearer becomes overheated. Clothing worn outdoors should be chosen in accordance with the following: (1) length of stay outdoors, (2) type of work, (3) flying or nonflying, (4) weather, and (5) the method of travel.

In general, if minimum dexterity is required or minimum movement is to be performed, one should clothe himself with several layers. This would apply to an individual who would be out in the cold for long periods of time. Such an individual should wear adequate head gear, such as parka, snow glasses or goggles, and scarf. He should probably have on a heavy or moderately heavy wool shirt and

trousers over the Navy underwear. A heavy wool shirt may or may not be worn over the other shirt. His outer garments should consist of the A-2 trousers with liners and a heavy parka which pulls completely over the face leaving only slits for eyes. The most desirable heavy parka is the Air Force parka. One disadvantage of a parka is that it obscures visibility except for a straight line in front of the individual. The removable fur-lined parka, used largely by AirDevRon SIX, was more satisfactory and popular than the attachable Army parka issued to the Seabees. With these two parkas, a muffler or face mask rarely had to be worn except with severe winds and blowing ice and snow. Over the wool shirt a wool sweater (either slipover or button type) was worn, over which the Army coat was placed. These coats and sweaters were quite satisfactory. The Army-type parka is buttoned to the coat and is a poorly designed but otherwise satisfactory garment. The Air Force parka which is attached to a coat or the Navy aviation issue parka which is a separate garment was preferred by most persons. If necessary, a third layer of trousers may be worn, but were seldom required at McMurdo. The A-1 trousers worn by the Seabees were satisfactory except for bulkiness. Vaporized clothing should not be worn by flying personnel because of its liability to burn in a crash.

Some disadvantages of the above clothing noted were: (1) shrinking of woolens upon laundering; (2) inadequate amounts issued to some personnel, though this was partially alleviated by obtaining clothing from personnel who did not need it, such as indoor workers; and (3) limitation of movement and dexterity.

Recommendations

1. That a wide variety of types of garments be provided so that each individual can select the combination that suits him best under actual working conditions.

2. That proper-fitting clothing should be provided.

3. That adequate amounts should be issued for individuals, depending upon the job to be performed.

4. That incoming summer personnel should be outfitted with adequate and proper clothing.

5. That there should be a reserve clothing issue center, with approximately 20 percent issued to the base population in reserve.

Little America

Outdoor Clothing

The outdoor clothing which was provided each man proved adequate in most respects. Actually, each individual had more protective clothing than he ever needed on any single occasion, and this allowed him to select an outfit from his seabag which was most to his personal liking and comfort. There was, therefore, considerable variation of apparel worn outdoors even though all were working under identical conditions. All cases of frostbite were confined to the exposed areas about the face and neck. No cases of frostbite of the extremities were noted. In only one case was the cold injury sufficient to produce vesication (blisters).

The clothing issued to Deep Freeze II personnel was the standard Army cold-weather type. The quantities, quality, and adaptability of this clothing is considered excellent for antarctic use. As in other things there were some shortages and some overages. Leather mittens and leather gloves were in short supply as well as light wool socks and foot gear. There were considerable variations in individual preferences for clothing among individuals and groups.

Navy issue cold-weather clothing is designed primarily for wet cold and to serve personnel for short periods of exposure. Although some Navy issue was available, the bulk of the clothing used was from the U.S. Army and was for prolonged exposure to dry cold, the condition prevalent in the antarctic. The decided advantage gained was the layer-design of this type of cold-weather gear, enabling personnel engaged in heavy manual labor to adjust the various liners and multiple layers to coincide with work performed and with the severity of weather. Mobility is thus gained and protection from the hazard of excessive perspiration.

The quality and workmanship was excellent. However, all clothing wore out rapidly because of hard usage, poor washing facilities, and a complete lack of dry-cleaning facilities, which resulted in the necessity to wash all clothing.

Pockets

Although some Army clothing items had adequate pockets, it is believed that many more are needed in all items of clothing. A man in such cold conditions carries all sorts of odds and ends with him during routine outside work. Since each clothing item generally covers the preceeding one and gloves must be worn constantly, it is extremely difficult to get into underclothing for pocket items needed. Circumstances dictate putting as much in the outermost garment as possible, and therefore having sufficient pockets in all clothing is important. The Army parka

is an example of lack of pockets. It has two excellent slash pockets, but the addition of breast pockets, straight side pockets, lower flap pockets, etc., would help considerably.

Facial Protection

The principal inadequacy noted was the lack of facial protection. Parka hoods were of some value but do not protect in high winds, and restrict vision. Surgical masks were used for work outdoors, and proved helpful in protecting the lower part of the face and nose. These, however, became frosted and uncomfortable after prolonged use. The fur hood was found to be too shallow. When worn with the winter cap, as it must be in extreme cold, the length from neck to the top of the head and from front to back was inadequate. The parka weight in some instances rests on the head rather than shoulders. The fur piece edge does not extend far enough forward to allow for formation of a sufficient air pocket in front of the face to fully protect the nose and cheek bones.

Handwear

Wool gloves were adequate for warmth when worn with large gauntlet mittens, but were cumbersome for work. The half mitten seemed to provide a fair compromise between adequate warmth and manual dexterity. The universally sized leather mittens were found to be inadequate because of lack of sizing. They are far too big for a small-handed man and a very large-handed man in some instances cannot use them. Although they may fit 90 percent of the personnel, the remaining 10 percent must have regular protection with sized mittens. Gloves, mittens, and inserts need to be provided in considerable quantities because of extreme wear. An assortment of types is necessary; for wintering-over personnel, each outdoor worker should be provided with about four pairs each of leather gloves and mittens and eight pairs of wool inserts.

Footwear

It was found that the variety and quantities of footwear issued were inadequate. The basic footwear issue was two pairs of Army white experimental rubber boots, two pairs of field shoes, two pairs of rubber overshoes, and one pair of fleece slippers (bedroom type). Few personnel utilized the field shoe-overshoe combination out of doors, except during the warmest summer days. The white rubber boots had inherent faults. Heavy work around camp tends to destroy this boot in a short time. The texture of the boot makes it conducive to nail punctures or other types of abrasives. Oil and grease used extensively in the garage and excessive persperation seems to hasten deterioration. Since production and delivery of the boot in quantities and

sizes required in Deep Freeze II was slow, many personnel received only one pair of these boots. One kind of footwear, or even the three provided for Deep Freeze II, is not considered sufficient variety. Mukluks, ski boots, and white felt boots also serve for change, and for use in special conditions. For example, vehicle drivers and aviators find leather ski boots or felt boots best because the white rubber boot is too large and cumbersome, thus insensitive for handling foot controls with precision.

Indoor Clothing

The greatest clothing inadequacy was in regard to light indoor clothing and shoes. A great part of the wintering-over period at Little America V was spent indoors, and the exposure to the severities of the antarctic climate was less than had been anticipated. Wool khaki shirts and trousers and the "boondocker" type of shoe were worn a great deal of the time, and there were insufficient replacements. It was found that it was of benefit to have a few articles of civilian clothing such as light sweaters or plaid shirts. The men appreciated the opportunity of dressing up in something other than the usual drab khaki military clothing which was provided.

Byrd

Four seabags of cold-weather clothing were issued to each Navy and IGY person prior to departure from Davisville, but part of the supply was lost in the air-drop at Byrd. Even with only two bags for most of the personnel, the clothing supply proved adequate in most respects for the work around the base. It was felt, however, that had a traverse back to Little America become necessary because of a base disaster, the clothing on hand would not have been adequate protection for the trip.

The combination of clothing most often worn for outside work at Byrd Station consisted of the following: waffle-weave "long johns," Seabee greens, A-1 pants with liner, field jacket with liner, parka and/or pile cap, light-green Army socks with heavy socks over them, A-1 white rubber boots, and leather finger-type gloves with liners, under large A-1 gloves with liner. This list varied according to individual likes and dislikes, the job assigned, and the weather conditions at the time. During the summer months the list would include sunglasses in most cases. The use of the finger-type gloves, while not adequate protection during very cold weather, did give protection for short periods when the large A-1 gloves had to be removed for manipulation of tools. The waffle-weave long underwear was preferred to the wool variety as being less scratchy.

In addition to the clothing supplied to individuals, a supply of heavy outside clothing, such as A-1 pants, field jackets, heavy gloves, and sunglasses, should be supplied each base for replacement of garments that wear out.

South Pole

It must be remembered that the South Pole is unique in that the cold is extreme and very dry. During the summer, temperatures may rise to almost 0 F, but during the winter, temperatures average -76 F (90 percent of the time below -58 F, 10 percent below -90 F), with an average wind of about 16 mph (gusts to 54 mph). Of importance, too, is the fact that once winter and darkness close in, outdoor work is minimal and of short duration.

The clothing provided for Deep Freeze II proved adequate in general under all conditions experienced, even though many improvements could be made in individual items and in the quantity of issue. While personal preferences as to individual clothing items varied, most preferred the Army issue items rather than the Navy vapor-barrier clothing. In temperatures below about -50 F, the impregnated cloth of the vapor-barrier clothing becomes very stiff.

Handwear

Improvements in clothing to provide the same warmth with less bulk would greatly facilitate outside work in cold weather. This is especially true with respect to handwear, where manual dexterity is achieved only at the expense of adequate protection from cold. A lightweight, flexible, fingered glove, electrically heated to provide proper warmth at low temperatures, would be the greatest single clothing asset to cold-weather work.

Starting from the innermost layer, the thin white cotton gloves found some use when one was working with fine parts outdoors. A slightly heavier variety would seem better, however, because these gloves do little in the way of retaining warmth. The emphasis should be on the fit in this item because a glove in which the fingers fold over is next to useless.

The woolen gloves and mittens representing the next layer were quite good, the mitten being the warmest. The trigger finger has no use at the South Pole and was an incessant nuisance. The Navy fingered A-1 mitten liner was also used, and proved satisfactory under the same conditions as the leather glove, though it lacks the windproof and snowproof qualities of the leather.

The glove covers were two in number, the leather gloves and the leather mittens. Both were very durable, but the leather glove is too cold for all but the calmest summer day. The leather mitten, on the other hand, found extensive use. If it were considerably longer or had a wristlet, it would be ideal.

The heavy gloves (mittens) were warm but were generally much too small. This final layer of hand cover must be fitted large. The mittens lasted quite well considering the use they received. One might predict, however, that each man would use two pairs during the year and leave little else but the fur for the next group. The palms gave out first and, once gone, made the rest of the mitten almost useless. If the leather palms could be made stronger, the life of the mittens would be greatly increased. The flexibility of the hand, however, must not be decreased any further. These mittens were a most convenient item. The long wristlet was most important in keeping snow out of the inner layers, and the straps were an important feature during working periods when the gloves were continually being removed for finer work. Once again, this item above all others must be properly fitted. The largest mitten should feel just a little loose when two pair of smaller gloves are worn within it. This is most important.

Footwear

The indoor shoe is the only notable deficiency. It should be warm but easily dried, sturdy, and rough-soled. A flat smooth sole is dangerously slippery on the light powdery snow which covers the ice floor of the tunnels. The decks were generally close to the freezing point, and the tunnels between buildings were usually in the -50's. The indoor shoe therefore had to be warm and yet not so warm that prolonged wear would make the feet perspire. With various combinations of socks, this problem could be solved.

The ski boot had the advantage that it would dry easily overnight and when used with two sets of socks in rotation, proved to be very comfortable. The disadvantage is the nuisance of lacing. The flight boot which the IGY personnel had was perhaps the most comfortable, but the fleece inside tended to retain moisture throughout the night. This was solved by placing small bags of silica-gel in boots overnight.

Both the Army soled mukluk and the Army white thermal boot were widely used, being worn by nearly all men for outside work. Both kept the feet sufficiently warm when properly worn, though at extreme temperatures (-80 F and below) endurance was generally limited to two or three hours, after which, even when engaged in moderate physical activity, feet began to get thoroughly chilled. In both items, the rubber itself became as hard as cast iron at temperatures below -40 F. This proved less of a problem with the mukluk, as the upper portions are of cotton duck, while the stiffening of the rubber in the thermal boots sometimes caused chafing of the leg. The mukluks, in coldest weather, were worn with two pair of felt insoles, one pair of cushion-soled socks, and two or three pair of ski socks, plus the felt sock. Under similar conditions, heavy socks were also worn with the thermal boots

instead of the normal one pair of cushion-soled socks, as at very low temperatures the frost line moved inside the boot. The smooth-soled mukluk was unsatisfactory around the base because of the slippery surfaces.

Felt boots, though worn on occasion by a few men, were generally unsuited for use at the Pole, as they provided adequate warmth only at temperatures above about -40 F. The sole of the felt boot was also extremely slippery on hard-packed, glazed snow surfaces.

Socks

The two main types of socks at hand were the cushion-soled ankle-length and the ski sock. The former proved very satisfactory, warm and tough, and is to be highly recommended. The bulkier ski sock also proved indispensable, and it is only suggested that the woolen socks be fitted somewhat larger since they shrink in laundering. Socks were usually worn in pairs, the inner cushion-soled and the outer ski sock; they were even worn indoors, depending on the type of footwear used.

Shirts

Although the woolen shirt is recommended for outdoor dress, a lighter shirt is indicated for everyday wear. The wool is generally too warm to be worn indoors over long woolen underwear. The flannel shirts which the men brought with them were most popular, not only because of their weight, but also because of their color. The woolen shirts were warm and durable, but had the most inconvenient aspect of having shirttails which were far too short.

Sweaters

Sweaters were satisfactory in all respects. The turtleneck sweater appeared to be the warmest and most convenient. The V-neck had no real advantages, and the buttons were only a nuisance.

Parkas

Of the two types of parkas available, the Army issue was by far superior. The Navy clothing became stiff and hard to manage in the -50 F to -60 F range, and although very warm, was generally too bulky. The Army issue was found satisfactory in warmth in the -80 F to -90 F range, especially when supplemented with the Byrd Cloth windbreakers. The down parkas of the IGY were warmer around the body and had a more adequate ruff, but suffered from easy tearing of the outer cloth. The Army parkas seemed extremely durable, and there is no need for improvement in their design so far as convenience is concerned.

Windbreakers

The Byrd Cloth windbreakers were a tremendous asset. For unit weight, they probably gave more warmth than any other item; and although the wind did not achieve the force at the South Pole that it did at coastal stations, the effects were still felt. At -90 F even a slight breeze makes a world of difference, so that windbreakers are vital. They proved to stand considerable wear and tear.

Trousers

The Navy heavy-duty trousers become stiff and hard to manage below -50 F. In general, the Army clothing proved entirely satisfactory. The part of the clothing which first showed wear and tear was the knees of the trousers, which took a beating during the construction period. Perhaps reinforcement in this area would be advisable. The woolen trousers were generally satisfactory, warm and durable. However, a number of the men preferred to wear khakis, which, although less warm, could be laundered. Cleaning fluid is therefore recommended for laundering of woolens.

Facial Protection

Because all the personnel suffered regularly from minor frostbite of the face, it appears that face masks are important. There will always be a certain proportion of men who will not cover their face no matter how good the covering provided. On the other hand, this item should be available. The issue on hand during Deep Freeze II was not satisfactory. The masks tended to become frozen to the beard; they slipped about over the face so that vision was intermittently disturbed; they were impossible to wear with glasses (because of the instantaneous fogging); and they soon became foul with mucus dripping from the nose. If an adequate parka hood is worn, the face mask is not required, though minor frostbite of the nose may be more prevalent when masks are not worn.

Sunglasses

The "Ray-Ban" glasses were found by most to be very satisfactory. Points in their favor were the wide coverage of vision, the lighter central band, and the convenient belt case. The metal rims were a disadvantage and caused frostbite at the contact point with the cheek. This disadvantage was remedied by narrow strips of adhesive tape over the rims. In one case, the glasses appeared to give a false perspective. This complaint was not experienced by others. In general, these glasses were good, especially for those needing prescription glasses.

The goggles (N-2) were used exclusively by three or four men who claimed that the convenience of having glasses pinned to one's cap ready for use at any time made these goggles the best. The field of view is definitely limited, however, and these goggles which lie flush with the face on all sides tend to fog as readily as the others.

The majority of the men chose the American Polaroid glasses for daily use. These are simple, effective, and appear to have less fogging than the others mentioned. The plastic frames, however, have a tendency to disintegrate, and it must be realized that the wear and tear on glasses is far above normal during the hectic work periods of the antarctic summer. The above-mentioned goggles with their simple headband are the best suited to these conditions.

If the best features of each of these glasses were combined into one item, the result might be a set of goggles with the Ray-Ban lenses but with a soft material for edging. The outfit should be made to clip to the cap for protection and easy reach.

Headwear

The field cap with the pile lining was entirely satisfactory if properly fitted. It was found warm, light, and durable, and the following comments are not so much in criticism as just food for thought. In cold weather the parka hood is ample covering over the eyes, and the visor tends to get in the way of the ruff, acting as a lever to turn the cap askew. It would be possible to extend the back of the cap into a semi-hood which would cover the shoulders and back of the neck. Such an arrangement would make a scarf unnecessary and would be most appreciated by those digging in snow mines where cold snow down the back of the neck is an unpleasant adventure. If the goggle were adopted in preference to the spectacle type of sunglasses, some clip or snap device should be built into the cap to hold the goggle band.

Underwear

It is recommended that personnel be advised to bring ample supplies of shorts and tops before their departure or that these items be made available in ship's stores.

Two types of long underwear were available, the woolens and waffle-weave. Both were satisfactory, although the latter proved to be somewhat warmer and less itchy. Both were very durable. The waffle-weave type had the unfortunate disadvantage that the waist size, if originally wrong, could not be readily corrected. Although it is true that clothing is warmer if oversized, this principle should not

apply to underwear. There are few occasions so unpleasant as when one gets fully dressed and a hundred yards from the station only to feel the innermost layer slip away toward the knees. With the woolen underwear, this was not the problem. On the contrary, shrinkage sometimes occurred to such an extent that the articles became unusable.

Nightwear

The pajamas were, if anything, too warm for comfort in the well-heated buildings. Simple cotton pajamas might be of more use, though the men tend to have individual preferences which are impossible to satisfy throughout. The robes were in general little used, although they seemed adequate in all respects. The slippers were most appreciated and in one case were worn as the standard shoe through the day. They were warm but the sole tended to disintegrate if worn regularly.

Recommendations

In general, the clothing was good. If it was found that one was cold when the temperature was -98 F, it was generally the fault of the wearer not the clothing. The few recommendations are relatively minor ones, but I would like to suggest the vest as an article which would find considerable use. Those who had them were quite enthusiastic. I would recommend dropping the Navy foul-weather clothing from the South Pole clothing list completely. It found little or no use during our stay.

The following comments are set forth with respect to specific items of clothing, and include comments based on field use under extreme conditions, and recommendations for improvement based on this experience.

Parka, Army, with liner: Excellent cold weather. Need for additional pockets. Hood generally unsatisfactory, as is too small. Should be enlarged to extend further out in front of face for greater protection against wind, and be deepened to allow more room for other head gear underneath.

Field jacket, with liner: Excellent under all but coldest conditions. See above for comments on hood.

Pants, field, with liner: Excellent all conditions. In combination with parka and liner, provides adequate protection when worn over waffle-knit underwear, flannel pants, shirt, and sweater, under all conditions experienced as long as wearer is moderately active.

Underwear, waffle-knit (Navy): Generally excellent. Buttons should be sewn on more securely and buttonholes reinforced.

Shirt, Army OD: Shirttails too short, sleeves too short, and cuffs too small to allow easy buttoning without constriction.

Pants, Army, OD: Very good.

Mukluk, cotton duck, rubber-soled (Army): Excellent under all conditions of dry cold; sole has good traction, but rubber will crack under extreme conditions (about -80 F and below). Some increase in height, about 2 inches, would allow top of mukluk to be more surely tied over bottom of pant leg. Two pairs should be provided each man, with 25 percent spares.

Thermal boots, white experimental (Army): Generally excellent. Rubber becomes solid at low (-80 F) temperatures. Insulation should be increased for use under such conditions.

Flight boots, fleece-lined: Excellent for indoor wear and brief periods of outdoor wear. Leather uppers cracked badly; these should be made of dry-tanned leather. Rubber also cracked at low temperatures. Two pairs should be provided each man.

Sunglasses: Both plastic-framed sunglasses and ski goggles were used at the Pole, with the former proving the more popular. As they are relatively easily broken, each man should be issued a minimum of four pairs of sunglasses. Metal-framed glasses should never be used; some were, and resulted in second-degree frostbite of both cheeks of the wearer, where the frame came in contact with the skin.

Hallett

Everyone received four seabags of winter clothing, two regular and two duplicates. Many complained because items of clothing they received were either too small or too large. Light clothing was used most of the time. A larger quantity of light clothing is necessary at this station. Heavier clothing was worn whenever it was required to stay out in the cold for several hours at a time and during storms.

Face masks were seldom needed at this station. However, goggles were worn during strong winds and snowstorms to protect the eyes from blowing snow and gravel. These could be worn for only a few minutes, after which they frosted and made it difficult to see.

Brown gloves with inner wool lining were preferred because they allowed free movement of the fingers. The amount on hand was considered insufficient. Mittens were always carried along in case the men were required to stay out for long periods of time.

Leather boots were worn most of the time. Some wore flight boots over the leather boots during the winter. These kept the feet warm and comfortable and it was noticed that perspiration of the feet was minimal. Thermal boots were worn during extreme low temperatures. They would cause sweating of the feet after two or three hours and the moisture would make the feet cold. Ski boots were similar to leather boots, but were seldom worn because they would drag dirt, gravel, snow, and penquin feces into the buildings.

Wilkes

The clothing proved reasonably adequate for the most part but was not in adequate supply in all cases. There was a wide variety of clothing available and considerable variation in the choice of individuals for their personal use.

Temperatures at Wilkes Station were comparatively mild. In work about the camp, enlisted men, who generally did heavier, dirtier work, wore the washable Navy utility cotton OD greens, usually with long underwear and "boondocker" high-topped shoes with cushion-soled and/or wool socks. The thermal boot was occasionally used by some who were outdoors a great deal. The parka saw little use about camp, some men preferring the Army coat, while others stuck to sweater and Navy jacket. The brown shell leather glove was most popular, but wore out quickly and was replaced by the shell leather mitten or light gauntlet, three-finger mitten.

IGY personnel doing winter fieldwork found the Army parka adequate, but most had personally purchased down jackets (Eddie Bauer Outfitters, Seattle, Wash.), which were lighter, warmer, and generally more comfortable, though not as sturdy, and were impractical for heavy or dirty work. During the summer season a sweater with windproof anorak and trousers were preferred. During the warmer months the Army ski boot was used almost exclusively for excursions away from camp until boggy snow and melt water made waterproof foot gear in form of overshoes on lightweight thermal boots necessary. For icecap travel in winter the mukluk and felt boots were preferred, though the heavy thermal boot was worn occasionally.

Handwear

Cotton and nylon contact gloves were used infrequently. Most persons preferred to keep their hands in well-insulated mittens, preferably with hand warmers, then to manipulate camera or theodolite quickly and return hands to the mittens again. Gloves were more practical than mittens most of the time. On the trail, mittens were sometimes preferred. Privately supplied, soft, pigskin contact gloves were somewhat warmer and were used regularly by one man. The shell-leather glove was preferred by Navy personnel because of its flexibility, but was not durable. The shell-leather gloves with knit liners were by far the best all-around handwear, but were not supplied in adequate quantities. They often make the difference between being able to do a job and not being able to. Civilians were not issued these, so preferred the shell-leather ski mitten. Large, pile-insulated, Army gauntlet gloves were clumsy but warm and were considered adequate for trail use. The noninsulated, three-finger gauntlet glove was much used in everyday work. Two pairs of Naval aviation, three-finger, shell-leather, fleece-lined gloves were privately supplied and considered by their owners to be more flexible and fully as warm as the heavy Army glove. Rubber dishwashing gloves (with or without liners) with corrugated areas on fingers for additional traction were found ideal for cleaning and skinning seals.

Footwear

The best-liked boot for the camp area was the warm, convenient, but not rugged, Air Force flight boot. The "boondocker" was adequate in the camp area but not outside of it, because its smooth sole lacked traction on snow, it was not warm, and not waterproof. The thermal boot was felt to be safe for any conditions met in this area, but was too warm in above zero temperatures, sweating was inescapable, and it was cumbersome. Nonetheless, this is an excellent and much-appreciated item.

On one occasion when a man had to walk 20 miles on the icecap in -25 F weather, the boot left his foot raw; but the canvas-topped mukluk worn by the civilian also making the trip did the same thing and was not as warm. The civilians were not issued the thermal boot and wore the canvas mukluk for the most part with good results.

The lightweight experimental thermal boot was perfect for summer use, though not warm enough for the icecap. Like the heavy thermal boot, it kept the feet warm even after immersion and filling with ice water. They were good for the temperature range of about -10 F to 20 F. For temperatures above 20 F field shoes with rubber overshoes or Army ski boots were usually worn. For inside wear field shoes, ski boots,

and flight boots were worn. Not enough flight boots were issued so that each man could be given a pair, and as they proved to be a very comfortable and practical piece of indoor-outdoor footwear it is believed that they should be included in the clothing issued to each man. Several men wore out one pair of ski boots and two pairs of field shoes before the year was over and were forced to wear shoes with holes in them as a result.

The most widely used boot for excursions near the camp area was the ski boot, which had the rubber lugs necessary for effective traction on the hard-packed snow of this region. This boot had the disadvantages of excessive weight, lack of insulation, and tendency to leak. Two men had lug-soled, mountaineering boots, which were superior. One of these had thin sponge-plastic insulation and would seem to be close to the ideal boot for this area. The felt boot and mukluk were the warmest and most comfortable boot for icecap temperatures. The glaciologists each wore out a pair of these during the year and would have preferred two pairs. Felt boots were tried also but were good only in dry calm weather.

The one area where a better article would be particularly valuable would be that of the all-around boot for hard snow and rock use. A slightly higher top, lighter lug sole, more waterproofed, and preferably lightly insulated boot would fill the bill.

Socks

The cushion-soled sock was excellent for use with thermal boots or with "boondockers" about camp. Ski boots were usually worn with one or two pairs of wool socks over cushion-soled socks. The felt boots and mukluks were worn with cushion-soled socks, one or two pairs of wool socks, and IGY-supplied felt socks. All these combinations were adequate for their purpose. Two men with Norwegian and Canadian natural-wool socks expressed preference for these.

Shirts

The light OD cotton shirt, while not warm, was washable and preferred by most working enlisted men. The Army wool shirt was preferred by many civilians, some wearing the tails tucked in and some wearing the tails out because of preference or shrinkage. Some of the civilians brought their own wool shirts, and the majority preferred IGY-supplied khakis during the warmer months.

Sweaters

Both high-necked and V-necked sweaters were adequate and worn by some over light undershirts in place of shirts. Somewhat better were Norwegian, natural-wool sweaters supplied by two men.

Coats and Parkas

The Navy jacket used with sweater or wool shirt was adequate during most of the year about the camp. The Army coat with liner was adequate and durable and with detachable hood could be used even in blizzards. The Army parka was warmer and provided more protection from blizzards, though it was slightly more cumbersome. The Army field jacket and outer parka were the most commonly worn upper garments. They were fairly durable and although very heavy were reasonably comfortable. Short jackets in general were unsatisfactory. The down jackets were much lighter, more comfortable, and warmer, though less windproof. The experimental vapor-barrier coats, like the trousers, were too heavy and cumbersome, and were subject to stiffening. The most popular trail garments during all except the coldest months were the colored windbreaker anoraks, which could be worn over a sweater or wool shirt and taken off and rolled into a light bundle for stowage if the wearer became too warm. Two men brought reindeer-skin and cormorant feather Eskimo parkas, respectively, but these were too warm and inconvenient for much use.

Trousers

Here, again, the washable OD cotton was preferred by most enlisted men. The civilians preferred khakis for use about the base during warmer months and used the Army outer, windproof trouser or wool trouser (though this item could not be washed without shrinkage) during the winter months. The Army field pants and outer wind pants were both worn a good deal and were fairly satisfactory. The slits to allow access to inner clothing leaked snow considerably during blizzards as did the pockets. Those who had down-insulated pants considered them excellent for use at temperatures below zero on the cap. The experimental vapor-barrier trouser was found too cumbersome, heavy, and stiff to be used pleasantly, with marked stiffening below -45 F.

Headwear

For headwear the Army hood with fur ruff, the Army pile field cap, and the Navy nylon fleece-lined cap were the most commonly worn in colder weather. Hoods were more comfortable than caps and were worn quite a bit. The Army pile-lined cap was quite adequate for all purposes, though inconvenient to wear inside parkas. The balaclava helmet was preferred for this application in winter and many used it with the anorak for all except the bitterest weather.

Underwear

Both the Navy and the Army types of underwear were worn and opinions differed widely as to which was superior. In general, if a man did not mind having wool next to his skin he would prefer the Army type. Regular short underwear was worn under the longs by most of the men. During December and January the use of long underwear was discontinued by most of the men. One civilian supplied his own long drawers with a slit seat which he found more convenient. Those who had Norwegian "string" undershirts preferred these to all others.

Ellsworth

The clothing supplied was considered adequate. The following improvements are suggested: Navy cold-weather clothing should be eliminated and replaced by Army gear. The length of the Army flannel shirt should be increased to enable the wearer to keep it inside his trousers. Some type of easily cleaned coverall should be included in the gear for drivers and mechanics to protect their cold-weather clothing from grease.

MEDICAL HISTORY

McMurdo

Medical Personnel

Deep Freeze I. On 20 December 1955 a party of approximately 30 officers and men from U.S. Naval Mobile Construction Battalion (Special) Detachment One and the staff of the Task Force Forty-three went ashore at Hut Point, Ross Island, McMurdo Sound, Antarctica, as the first step in the establishment of the U.S. Naval Air Facility. Medical personnel consisted initially of two medical officers and a hospital corpsman. A second corpsman joined the shore party late in January. A complete and adequate field kit for the advance party had been packed at Davisville, Rhode Island, but did not accompany the landing party.

Except for the period 22 December to 25 December 1955, the medical party ashore had constant access to one or more of the ships of the task force. The distance from the ships to the camp across the frozen sea ice decreased from 60 to 5 miles as ice breaking progressed. Except for a few days of bad weather, transportation by helicopter, weasel, or tractor trains was readily available for the evacuation of patients and the movement of supplies. After 30 December 1955,

patients requiring bed care were evacuated to the various ships. Professional consultation with medical and dental officers of the ships and with the Senior Task Force medical officer was always available. Cooperation of the ships' medical staffs in these support activities was excellent.

Medical personnel wintering over consisted of a medical officer, a dental officer, and two hospital corpsmen. There were many dental complaints and the presence of a dental officer was very important to the health, efficiency and morale of the camp.

The professional specialty of the medical officer was internal medicine and his only surgical and orthopedic experience was a three-month training period at the U.S. Naval Hospital, Bethesda, Maryland, prior to the departure of the battalion from the CONUS. One corpsman was a neuropsychiatric technician; the other had no special rating. Medical personnel were limited, therefore, in surgical experience.

The time of the medical officer was devoted exclusively to the sick bay and related medical activities. The corpsmen were called upon, however, to assist in nonmedical work about the camp when their medical duties permitted. It is considered that for a camp with a population of over 50, two corpsmen are necessary, for there are numerous occasions in which two will be needed for procedures in sick bay and to attend to seriously ill patients. Much of the time, however, medical duties will be light, and corpsmen should expect to be employed at important nonmedical tasks.

Deep Freeze II. On 16 October 1956 the first aircraft of the season arrived at McMurdo Sound from New Zealand, terminating the period of isolation. The camp population increased rapidly and messing, housing, and sanitary facilities were taxed to the limit. The population was about 360 at the maximum and remained steadily over 280 throughout the summer.

During the month of October 1956 all but one hospital corpsmen at McMurdo were incapacitated for three to six days each. Chronic fatigue increased the susceptibility of medical personnel, as well as others, to the numerous upper respiratory infections that spread through camp.

With the first plane in October, a VX-6 flight surgeon arrived at the base. He participated full time in medical activities throughout the summer. One of the wintering-over corpsman accompanied the party to the Beardmore Auxiliary Air Base and another accompanied the construction party to the South Pole. Since air evacuation would be available from these outposts, the corpsmen were equipped

only with first-aid materials. With the deployment of the wintering corpsmen, their places at McMurdo were taken by three VX-6 corpsmen. The presence of these men provided adequate coverage during the summer, and without them the medical department would have functioned much less efficiently.

The frequent flights between New Zealand and McMurdo Sound during most of the summer made possible the evacuation of seriously ill or injured personnel. This was a great aid in the proper management of casualties. Eight persons with acute conditions were evacuated by this means. On two occasions an Air Force medical officer was flown in to attend evacuees.

The wintering-over medical staff for Deep Freeze II originally consisted of a flight surgeon and one, well trained, second-class hospital corpsman, who was an operating-room technician. Because of the high incidence of sickness during the summer, an additional corpsman from VX-6 agreed to winter over. During the entire winter corpsman help was at a premium because of heavy sick lists and the incapacitation of one corpsman during part of the winter with a leg injury. Both corpsmen, averaged twelve hours duty per day for seven days a week, and in some instances worked as many as twenty-seven hours continuously. Following the helicopter crash in July 1957 three additional men, all nonmedical ratings, were chosen to work in sick bay to help with routine work. Also at this time sick bay was expanded to include the entire building known as Dufek Hall. McMurdo was thus essentially converted from a minor dispensary, with limited space, into a full-time understaffed hospital.

Conclusions. During the summer air operations it is imperative that McMurdo have at least four hospital corpsmen and preferably an additional flight surgeon. Two of these corpsmen are needed on a twenty-four hour basis at the runway. A minimum of one corpsman per twelve-hour shift is required for the routine functioning of the sick bay. If hospital corpsmen are required for explorations and expeditions, such help should be provided in addition to the above. Further, one senior corpsman should be kept in New Zealand during the summer to facilitate the handling of evacuated personnel.

Health Problems

Accidents were the greatest health problem during the winter of Deep Freeze I. Except for fractures and one severe instance of carbon monoxide poisoning of a man traveling in a weasel, these were minor. It is notable that no particular health problems were found which could be attributed either to cold climate or to isolation. The introduction of infectious disease by the transient summer personnel, the hazards of flying, and the dangers of ship off-loading on deteriorating bay ice presented the greatest medical problems during the summer months. Of these, aircraft accidents were most disastrous. During air operations, a corpsman was on duty at the airstrip.

Incidence of Illness. It was anticipated that the end of the period of isolation would result in a large increase of the incidence of infectious disease in the camp. This was abundantly true in the case of respiratory infections. In the four weeks subsequent to the arrival of the first plane, an estimated 75 percent of the 250 people at camp developed acute respiratory disease. The pattern was fairly characteristic. Sore throat and/or coryza were the first symptoms, followed in three or four days by bronchitis and cough. The cough usually subsided in ten days to two weeks, but in many cases persisted for several weeks. At first, fever was unusual, and the incidence of apparent bacterial secondary infection — otitis, sinusitis, tonsillitis, or pharyngitis — was low. As the summer progressed, however, these complications increased in frequency. It is interesting that summer personnel as well as the wintering group were widely affected by respiratory disease, suggesting the presence of infectious organisms, immunity to which was low in all Americans. An obvious possible source of such would be New Zealand, through the incoming personnel. The overcrowded condition of the camp during the summer is probably responsible for the very high incidence of respiratory infection. That outbreaks of more serious illness spread by respiratory passage did not occur is probably purely fortuitous. With the inadequate galley space and sanitary facilities during the summer, it is also only luck that serious gastro-intestinal disease did not appear. The last plane departed 24 February, and the last ship 13 March 1957. Shortly after this, most respiratory infections abated.

Minimal respiratory infections occurred in midwinter. Only an occasional cold and one or two cases diagnosed as "influenza" occurred during the isolation period. Many people, however, were noted to have an occasional dry, nonproductive, nonincapacitating, hacking cough, accentuated by the dusty, overcrowded, overheated living quarters. Undoubtedly, new organisms are brought into the antarctic at the end of an isolation period. Susceptible members of the wintering-over personnel can certainly develop respiratory complaints at this time. It was noted that more personnel developed "colds" when traveling into the more temperate and/or torrid zones enroute home.

Epistaxis and vasomotor rhinitis occurred in about six personnel at various times during the winter. This was particularly true when they were exposed to the extreme cold while working outdoors.

The urinary complaints were mostly of staphylococcal and/or streptococcal origin. It is possible that the polyvalent influenza vaccine, given to 99.0 percent of all personnel wintering over and/or the monovalent influenza vaccine may have had an attenuating effect upon this disease. Monovalent vaccine was not given to all personnel, but was given to a large percentage. Morbidity time of this disease was one to ten days per patient.

Injury. From April to September was the period of most accidents to winter personnel. The reason for traumatic injuries were basically as follows: (1) hilly, icy terrain; (2) aircraft accidents; (3) visual obstruction due to blowing snow and bulky clothing; (4) impaired efficiency in cold weather; and (5) winter darkness. Of the 87 people who spent the winter of Deep Freeze II at McMurdo, 15 had at least one plaster case applied during the winter, and one was killed instantaneously in an aircraft crash.

Minor lacerations occurred, but were not common because most men exerted maximum care in handling machinery and while working. Burns were the major surgical problem, particularly in the winter period. By far the most serious burns were those of the patients from the aircraft crash, and included third-degree burns of the eyes, face, hands, and lower extremities.

A grave problem was the transportation of survivors from the scene of an accident to camp. This problem was not solved at McMurdo during Deep Freeze I. Helicopters probably provide the best all-around solution to this problem, though they are unable to operate in extremely cold weather. Rapid-moving surface vehicles such as weasels or Sno-Cats would be useful. In Operation Deep Freeze I at McMurdo, a helicopter was infrequently available for transportation of the injured, and surface vehicles were in such short supply that other demands precluded the reservation of one for emergency medical department use. Future planning of cold-weather operations should remedy these inadequacies.

Climatic Effects. Diseases and conditions referable to cold weather were not serious in the winter. A few cases of cold sensitivity and frostbite occurred. Lacerations on hands seemed to heal somewhat slowly, particularly in those whose hands were exposed to the cold in the course of their work. Otherwise no ill effects were observed.

One case of cold sensitivity, of a person who constantly worked indoors, was a serious problem, and he eventually had to be transferred. This individual developed Reynaud's disease. Interestingly enough, he rarely drank and never smoked. Another interesting case was that of an individual who arrived with the incoming summer support personnel and very promptly developed marked, slightly pitting pedal and finger edema, which was accentuated by exposure to the cold.

Frostbite of all degrees occurred, but most of the time only of first and second degree. The parts most affected, in order, were usually ears, nose, face, hands, and feet. No cases were severe enough to contemplate heparin therapy. It is believed that, with rare exception, frostbite is usually the result of one's own carelessness. To prevent it, personnel must be properly educated in how to clothe themselves properly in cold climates.

Snow blindness, of course, gives none or minimal warning signs until too late to prevent symptomology. This was not a great problem, for personnel were instructed in the use of proper glasses and goggles. From mid-October to mid-March, protection of the eyes from light is necessary to prevent snow blindness. The importance of preventive measures was constantly emphasized to camp personnel, and the incidence was low. The cases which did occur were principally persons newly arrived at the base who were inadequately indoctrinated in protective measures.

Cold weather increases the basal metabolism, and diet should be proportional for calories utilized. However, probably only 500 calories more would be required per person to perform the same job in Antarctica as elsewhere. Fat consumption is higher, as fats are more easily tolerated.

Psychological Problems

Psychological problems were numerous. Those illnesses of a "neurosis" category were: (1) minor anxiety; (2) insomnia, particularly in mid-winter; (3) tension headaches; and (4) psychosomatic manifestations. Additional cases of a more serious or "psychotic" nature included depression reactions and latent schizophrenia, accentuated by periods of acute exacerbation.

One man developed a frank psychosis and for most of Deep Freeze I was unable to work. This man's suitability for wintering over had been questioned on the basis of his health record prior to departure from the U.S., but a psychiatric consultant had finally cleared him. Except for this individual, emotional problems in Deep Freeze I were not incapacitating. The men who wintered over were all volunteers; all were petty officers with a higher than average maturity of outlook; all well understood the reasons for being in the camp. The amount of work was sufficient to keep all hands busy throughout the entire winter. Most individuals suffered mild depressions with homesickness and feelings of frustration but insight was invariably good. Absence of mail was keenly felt but was greatly compensated for by the freedom with which radio messages could be sent home.

The size of the Deep Freeze I wintering party, 93 in all, proved to be advantageous with respect to interpersonal relationships. With this number, variety in personal contacts was possible and the problems related by smaller isolated groups rising from the relentless close associations of small numbers of people was avoided. Occasionally an argument grew heated and tempers flared, but no insufferable personnel antagonisms were manifest.

Insomnia deserves mention as a very frequent and often troublesome complaint. It was at its height during the darkest weeks of the winter night while physical activity was least. Some men continued to complain even though doing strenuous

work, and some were troubled throughout the spring and summer. So common was insomnia that it was given a familial name — "the big eye," an aptly descriptive title. Questioning of sufferers revealed, in almost all cases, that mild homesickness and depression combined with the irregular sleeping habits resulting from the polar solar cycle were important factors in causing "big eye." Frequently, mild sedation for a few nights was sufficient to restore a satisfactory sleep pattern.

Screening of Personnel

The need for adequate screening of all persons going to the antarctic cannot be overemphasized. Many of the nonaccident cases, who were admissions to the infirmary, should have been disqualified for antarctic duty. These would have been disqualified had the requirements for deployment to Antarctica been followed by the various fleet and other commands. The screening in Davisville for wintering-over personnel for Deep Freeze II was excellent.

Less than 7 percent of the McMurdo MCB-Special wintering-over personnel should have been replaced; 20 percent of VX-6 personnel and about 60 percent of "last-minute arrivals" should have been replaced. Of personnel arriving in Antarctica for Deep Freeze III, one could qualify the screening as follows: ComNavSupFor Antarctica — excellent; VX-6 — excellent, except for October III personnel; Naval Support Unit THREE wintering-over personnel — good; and Naval Support Unit THREE summer personnel — completely unsatisfactory. The latter, when reporting ill to the infirmary, stated they had never seen a doctor prior to deployment with reference to any history or physical examination for antarctic duty.

It is imperative that all personnel being deployed to Antarctica meet the history and physical requirements set forth in the CTF-43 Operation Plan.

Research

Although some research was planned by the medical officer at McMurdo during Deep Freeze II, very little was carried out with the exception of the neuropsychiatric and gamma globulin respiratory projects as outlined by BuMed. The first project consisted of giving certain neuropsychiatric tests three times during the year: immediately before departure of the last transportation, in midwinter, and one week to one month prior to the arrival of the first personnel after the winter isolation period. The first series of tests were given to only a few people because the tests were not located until a few days before departure of the last ship in mid-March. The confidentiality of these tests was assured to the men; however, many expressed resentment at the medical department. Opposition to even signing or taking them was experienced by about 30 to 40 percent of the personnel, and a few in the later periods refused to even sign their name because of the extreme personal nature of some of the tests.

The second project was initiated one week prior to the influx of new personnel. Ten cc's of gamma globulin was given intramuscularly to approximately one-fourth of the wintered personnel; vitamin A, 50,000 units, was administered orally every other day for a month to another one-fourth of the group; while another one-fourth were given both the vitamin A and gamma globulin. The remaining one-fourth were used as controls and given nothing. Only volunteers were given medication. Cooperation of all men in this program was excellent. One interesting note is the preliminary observation that some wintering-over personnel given vitamin A and/or gamma globulin did not become ill until as much as three weeks after the first arrival of new personnel, indicating some possible protection by one or both of the treatments.

Alcoholic Beverages

On the basis of 14 months experience in the antarctic, it is recommended that spirituous liquors should be available to personnel in isolated bases for morale and recreational purposes. Control of the distribution of liquor is properly a function of the command rather than of the medical officer. The provision of alcoholic beverages free of charge by the command seems fundamentally unsound in that responsibility for its use is removed almost entirely from the individual. In a sense, such dispensation may be considered to imply encouragement of imbibing by the command and the medical officer. On the other hand, liquor dispensed through properly organized messes and procured and paid for by the individual user is taken much more directly upon individual responsibility, and though with the command's consent, certainly without a hint of encouragement.

Policies for the use of alcohol, whiskey, and brandy were established during Deep Freeze II by the flight surgeon and the local command. There were no flagrant abuses of alcohol. Essentially, men returning from work were allowed a "shot" of whiskey or brandy in sick bay, provided they were not going into the cold again. A few base parties were held, and at this time, a limited amount of liquor was dispensed in accordance with medical and command rules. It was not dispensed to individuals who were unable to handle it.

Little America

Medical Facilities

Early in the construction phase, a first-aid facility was provided at Little America. At this time, the medical department was dependent upon ships of Task Force 43 for medical support. Medical personnel were primarily occupied with the task of collecting supplies and equipment, and the actual establishment of

the permanent medical facility. The medical department functioned entirely independently during the wintering-over period. No logistic support or evacuation of seriously ill was available from 10 March 1956 until 18 October 1956. Following the return of daylight, there was a period of renewed activity. Tractor-train operations to Marie Byrd Land required a medical department representative. Air operations and off-loading of cargo ships and transportation of material to the camp required medical coverage. The increase of population at Little America from 73 to 240 during the summer of 1956-57 produced increased local responsibility of medical personnel.

During the antarctic summer months 1956-57, medical care was augmented by naval ships in the Kainan Bay Area. During the months of winter isolation (10 March 1957 — 12 October 1957) the medical facility again operated independently. Air operations at Kiel Field, 1.2 miles southeast, were covered by the medical department.

Medical Personnel

The medical department at Little America had a medical officer and two corpsmen during the winter months of Deep Freeze I, with the addition of a dentist at the beginning of Deep Freeze II. With the base population at 73 for Deep Freeze I and 109 for Deep Freeze II and all activities confined to the immediate vicinity of the base, this number of personnel was considered adequate to cover most eventualities. During the spring and summer of 1956 - 1957, the commitments of the medical department increased with the increase of population and construction activities. One corpsman accompanied the Marie Byrd Land tractor train. With such limited personnel at the main base, during a period of aviation activity, construction, trail operations, and ship off-loading there would have been a serious compromising of medical care in the case of serious illness or multiple accidents. Fortunately, additional corpsmen were made available to Little America by VX-6, thereby helping to relieve a serious personnel shortage.

Personnel Requirements. A medical officer is required at all times at the main base. He should be either an experienced general surgeon or orthopedic surgeon. The greatest hazard to health in the antarctic is that of possible serious injury. This fact makes the presence of an experienced surgeon essential. It was felt during Deep Freeze I, II, and III that at least two corpsmen are required at the main base in order to afford ample medical care both at the main base and to units operating away from the base. At least one of the corpsmen should be an operating room technician, and he should remain at the main base at all times. It is true that two corpsmen are not required for the day-to-day function of the medical department, but this number of corpsmen must be on hand in order to meet any anticipated need,

and also to provide medical department representatives to units of more than 10 men operating away from the base. During the winter months, when the medical department has little work, corpsmen can be utilized on nonmedical details as necessitated by the work requirements of the base.

During the spring, when ships are arriving and off-loading, the ships should provide medical department representatives to cover military passenger personnel as well as the off-loading operation. These medical department representatives should not be those selected to relieve wintering-over personnel, as their primary responsibility after arriving on the ice is to be phased into the medical operation at the main base by the incumbent personnel during the short period before the ships depart. During the spring and summer 1956-57 the responsibilities of the MCB (Special) Detachment BRAVO corpsmen aboard ship prevented them from getting to Little America until after the departure of Deep Freeze I personnel. This, coupled with the arrival of the relieving medical officer on the same day as the departure of the Deep Freeze I medical officer produced a serious drawback to the smooth integration of the new wintering-over personnel.

Health Problems

Antarctic Pathology. The concept of antarctic medicine is misleading, for it implies that there is pathology unique to the area. In actuality, the problem has been one of having the means of treating the usual disease entities commonly seen in Stateside medicine. During the thirteen-month period of Deep Freeze I no illnesses of a serious nature were observed that could be attributed to the environment or climate which was encountered. No exotic antarctic diseases were discovered. Most medical problems observed were those which would be seen by a medical officer assigned to a construction battalion in any theater of operations.

Although the pathology was not unique, the means which are available for the treatment of any individual illness might be limited by the compact nature of the antarctic medical facility. Compromises are frequently necessary in treating diseases which would offer no therapeutic problem under more usual circumstances with more extensive facilities. At Little America the isolated location prevents the evacuation of seriously ill or injured during the winter. There is a lack of an immediate source of supply of medical material, and consultation services are not available. The medical facility in the antarctic must, therefore, be self-sufficient and capable of providing the broadest possible degree of medical and surgical care for an extended period of time, and still not exceed logistic capabilities, which are limited by difficult terrain and great distances.

Incidence of Illness. There were few colds and other acute infections and respiratory diseases during the Deep Freeze I wintering-over period. The first cold observed was in a man who arrived on the first aircraft. The first cold reported by members of the wintering-over party was on 4 November 1956. The peak incidence of colds was from 10 to 14 November 1956. A second epidemic of colds occurred in January following the arrival of spring construction personnel. All colds seemed to be aggravated by low humidity within buildings. Sore throats not associated with colds, fever, or exudate were probably due to dehydration of mucous membranes when sleeping in the extremely dry atmosphere within the barracks. In January and February 1957 there was a high incidence of respiratory infections of all types which was aggravated by the overcrowded camp conditions at that time. Approximately a third of the newly arrived personnel had upper respiratory infection. These were mild, but the symptoms were aggravated by the low humidity.

Dermatologic conditions accounted for 219 outpatient visits, which is more than any other type of pathology observed. This great number of visits in many cases is due to the persistent nature of many dermatologic conditions which require repeated daily treatments. Diarrhea was fairly uncommon at Little America. Nosebleed was noted in one individual particularly when he spent long periods outdoors in low temperatures and then returned to the warmth within the buildings. These episodes were of short duration and were controlled somewhat by using polyhexedrine inhaler; packing was not required. Conjunctivitis was not associated with exudate in any case. There was burning of the eyes with photophobia in some cases, and superficial and deep injection. Some cases were undoubtedly milk forms of snow blindness; others were due to chemical irritants within the garage and shops. There were no clearly recognizable cases of snow blindness during Deep Freeze I. Transient nonfixed brandycardia occurred from time to time in sick call patients. Symptoms were vague and transitory; no related causal factors could be determined. The heart rates were noted to revert to normal in a short time with no therapy.

Several cases of metal fume ague occurred in personnel welding galvanized steel. These were shortly reversible with only one day of lost time. Zinc fume poisoning was noted in four cases. Several instances of probable nitrite intoxication occurred during demolition with TNT and cordite shape charges. These cases were quickly reversible.

During the winter months of isolation there was only one case of illness which might be considered communicable, and that was herpes zoster. One case of tonsillitis occurred late in the summer of 1957 in a new arrival. Many personnel arrived in October 1957, and with this increase in population the incidence of acute URI increased sharply. Approximately a third of the newly arrived personnel

were symptomatic with all types of respiratory and naso-pharyngeal infections. Five days after the first new arrivals in mid-October, two cases of URI were noted in wintering-over personnel. By 28 October, four cases of mild flu-symptoms were seen; one in a new arrival and three in wintering-over personnel. These were the only incidents of influenzal type illness that occurred. Before the ships departed in February 1957 there were two known cases of infectious mononucleosus aboard. Three and one-half months after the departure of the ships, there appeared the first clinically detected case diagnosed as probable infectious mononucleosus.

Surgery. In general, the surgical procedures performed were minor in nature, and the majority were elective. None of the pathology treated was produced by the adverse environment of the antarctic. Methods of treatment were those which would be used in a more "civilized" medical facility, but the degree of difficulty encountered in performing any of these procedures was increased by the peculiar factors presented by location. The limited water supply, personnel limitations, the fuel-operated autoclave, etc., were all problems which had to be faced. Preparing for any major surgical procedure was a time-consuming task. The actual performance of the surgical operation in the antarctic is no different than elsewhere; the biggest difference is the fact that the medical officer and his corpsmen have to make all preparations and do all the other tasks which usually are done by many others in a hospital.

Climatic Effects. Although the antarctic has an adverse climate with winter temperatures ranging as low as 78 F below zero, the objective of those planning cold-weather operations is to provide each individual with a normal immediate environment by means of proper clothing and adequate shelter. The fact that this objective was attained to an impressive degree at Little America makes it difficult to evaluate the effects of prolonged exposure of personnel to adverse climatic conditions.

During the period from November through February, temperatures are frequently in the thirties; during December and January, temperatures rarely drop below zero. In addition, the sun's rays are sufficiently strong on clear days that the radiant effect is quite noticeable, particularly when wearing dark clothing. The major portion of outdoor work is done during this relatively "mild" four-month period from November to February.

Working parties at Little America had to perform considerable work outdoors when the temperatures were as low as 70 F below zero. However, all work performed at these low temperatures was in the immediate vicinity of the base, and exposure beyond the point of extreme discomfort was not usually necessary. The usual length

of exposure was rarely greater than four hours. As temperatures dropped to low levels and wind velocity increased, the period of continuous exposure was reduced according to dictates of comfort.

General or local ill-effects of cold of a major nature were not observed. Twenty-one cases of minor frostbite occurred mainly during the twilight periods, with outdoor work at very low temperatures. For the most part, these were first-degree and involved fingertips, nose, cheeks, and ears. The incidence of frostbite was probably higher than records indicated. In most cases those who received minor frostbite while at work did not report to the sick bay for treatment.

The actual snow blindness danger was limited at Little America Station due to the relatively few days permitting maximum short-wave dispersion. These days are reported to be those with bright sunlight with moderate haze. Tractor drivers within glass-enclosed cabs were afforded protection from any ultraviolet radiation. Individuals were known to drive 1200 miles across the ice on the Byrd tractor trains without protective glasses, and they had no ill effects.

Psychological Problems

The adjustment to the severe climatic conditions is but one facet in the over-all problem of adjustment to the antarctic environment. A more important factor encountered in polar operations is the demand upon individuals at a wintering-over base to be able to adjust to the absolutely isolated and extremely confined living circumstances imposed by the environment. Exposure to cold is temporary and intermittent, and can be alleviated by proper clothing and shelter. In constrast to this, the exposure to the circumstances of isolation and confined living is continuous and inescapable. It is of greatest importance in polar operations that all measures be studied which might enhance the process of adjustment to this peculiar living situation, as it has great bearing upon both the physical and emotional health of the personnel involved.

In general, the adjustment of the wintering-over personnel at Little America during Deep Freeze I was excellent. There was no case of severe emotional disorder during the 14-month period. There were two individuals who became sufficiently disturbed to necessitate their removal from the work situation and confinement to bed. In these two cases recovery was prompt, with return to full duty within two days. Otherwise, despite the unhappiness of some individuals some of the time, there was harmony during the entire wintering-over period. Group morale remained high.

No psychiatric complications of a major nature occurred during Deep Freeze II. Four individuals of the 109 had stereotyped personalities and a rigid interpersonal structure which required the adjustment of the remainder of the camp. One young

man had a transient bout of globus hystericus. There were several other cases of minor conversion symptoms. These occurred, peculiarly enough, with the return of sunlight in August. This was at variance with the condition described by the Greenlandic Danes as "morkepip" (darkness mania).

Insomnia was noted especially during the winter night, possibly due to restlessness caused by relative inactivity combined with the fact that many individuals became aggravated with the environment and took their aggravation to bed with them.

Screening of Personnel

The excellent emotional adjustment to the isolation and confinement of Little America was not due to the fact that there was any good method of selection of candidates for wintering-over, but was entirely fortuitous. It is unfortunate that more definite information concerning the screening of personnel for isolated cold-weather duty is not available. This subject is the most important continuing problem for the medical officer, with the possible exception of major surgical treatments.

The following observations are submitted: A large camp population (over 50) can absorb some otherwise unacceptable personnel for this type of duty. Simple psychometric testing is not adequate in the initial screening of personnel. Some aspects of inadequate stateside adjustment do not necessarily preclude acceptability for this type of duty. In other words, some types of "oddball" would fit in better to an "oddball" situation. What is ordinarily appreciated is the necessity for exclusion of obvious psychoneuroses or psychosis. There exist, however, certain minimally disturbed individuals who can create an unpleasant social situation. A mild, normally pleasant and productive megalomaniac can create a most disturbing situation by the very nature of being stereotyped. Lack of flexibility in personality structure, with poor group adjustment, can be a problem which could be disastrous in an acute situation. (The problem may also be a failure of the group to adjust to the individual.) Personnel who would have difficulty with moderate alcholic inhibition (i.e., consistently drink to excess) are those with sufficiently disturbed psyche as to be precluded from duty of this type.

Wintering-over medical officers should be assigned to their units at the earliest possible time in order to afford them the opportunity of observing the men in the actual living and working situation. It is felt this is more valuable than formal psychiatric examination in evaluating wintering-over personnel.

Research

Cold Sensitivity. No specific program was undertaken by the medical officer to study physiological effects of cold. One such program was carried out by the Arctic Aeromedical Laboratory, Ladd AFB, Fairbanks, Alaska. These studies were designed to investigate so-called "acclimatization" to cold and consisted essentially of the following:

1. Periodic recordings of basal metabolic rate.

2. Study of response to a standardized cold exposure in a specially constructed cold room. This consisted of indirect calorimetric data, recordings of skin and rectal temperatures using telethermometers with thermocouples, and observations of shivering.

3. Studies of changing local acclimatization (manual dexterity tests with cold exposure, and changes in vascular reactivity as observed in response to immersion of finger in ice-water bath).

4. Physical fitness tests using a modification of the Harvard two-step test.

5. Field thermal balance studies (heat production and body temperature change in outdoor conditions).

6. Nutritional survey. Food weighing with estimation of simultaneous energy expenditure. Measurement of body fat changes using skin-fold calipers.

A physical examination was conducted monthly at Little America on approximately half of the wintering-over personnel. Most of the camp population were interviewed and examined at least twice during the year; 40 personnel were followed more closely with 4 to 6 periodic follow-ups. Physical examination was brief; it included body weight, blood pressure, and pulse determinations. Direct effects of cold were difficult to assess. Whether or not measurable physiological adaptation occurs after chronic exposure is yet to be unequivocally demonstrated. Even though personnel at Little America were in a cold environment for approximately one year, actual cold exposure was intermittent and consistent outdoor workers were rare. This experience was quite different from the rugged dog-sledging explorations of the past. Most of the published work on man in cold environments concerns itself with mechanisms of heat transfer, metabolic rate, and peripheral circulatory changes as a result of "standardized" cold exposures.

Nutritional Survey. During September an attempt was made to record the food intake of five outdoor working Navy personnel. From preliminary screening of available raw data it was apparent that the ordinary adult male dietary intake of 2800 to 3200 calories per day was rarely exceeded in the small group of outdoor workers studied. Although vitamin supplementation was not thought necessary, as the months wore on and eating habits became erratic for some individuals, vitamins were supplied freely on the mess hall tables. In this regard, one case only of glossitis, skin rash with brachial neuritis, was seen. This was an aviation rate, who slept at the airfield and had not been coming into camp for regular meals. The symptoms subsided with oral vitamin therapy. Although there were marked variations in weight change after nine to eleven months of antarctic duty, there was an average weight gain of 6.45 pounds among the 71 personnel observed.

Gamma Globulin Inoculations. Prior to arrival of new aircraft in Deep Freeze I, 32 personnel were inoculated with 10 cc's of intramuscular globulin poliomyelitis immune (human). These personnel were followed individually for a 30-day period following the planes first arrival and compared with a control group of 50 noninoculated randomly selected civilian and military wintering-over personnel. The approximated incubation periods of severe URI in inoculated and control groups showed no significant differences. Because of the uncertain arrival date of the first aircraft, gamma globulin was given about a week prematurely (12 to 20 days before first exposure). During October and November, influenza inoculations were given and tended to obscure observations of the gamma globulin prophylaxis.

Alcoholic Beverages

The medical officer at Little America was put in the unique position of having to bear the responsibility for the issuance of medicinal alcohol, brandy, and whiskey for recreational purposes. The medical officer does not disapprove of the action of the commanding officer in regard to the policies of distribution of medicinal alcohol at Little America but does condemn the policy of officially prohibiting the establishment of wine messes and the consumption of alcoholic beverages on the one hand; and then approving the requisitioning of copious amounts of medicinal alcoholic beverages on the other hand. This apparent duality of policy resulted in a situation whereby both the commanding officer and the medical officer at Little America authorized the issuance of medicinal alcohol in violation of instructions as set forth in the Manual of the Medical Department. This violation of established policy was done in good faith with the desire of providing for the best welfare of the personnel at Little America. It is felt that issuing, or controlling the distribution of alcohol for recreational and/or nonmedical purposes is a command responsibility, and that it was unfortunate that existing policies made it necessary for the medical officer to assume any part of this responsibility.

Conclusion and Recommendations. 1. A firm policy of no alcoholic beverages other than medicinal could be established and strictly adhered to if the wintering-over candidates are given prior knowledge of the fact that no alcoholic beverages will be available. This solution is simple and workable, but would require selection of officers and men who would be willing to tolerate abstention from alcohol for a one-year period.

2. Alcoholic beverages can be consumed in the antarctic if the issuances of these beverages is kept under the complete control and responsibility of the command. The most feasible method of accomplishing this is by the establishment of an authorized club or wine mess.

3. It is the feeling of the medical officer that the distribution of medicinal brandy or whiskey to individuals who have been engaged in particularly hazardous, exposed, or otherwise difficult assignments is not only unwarranted from the medical viewpoint, but is detrimental to morale. In such instances, particularly when medical alcohol is the sole supply, the selection of individuals for the "reward" of brandy becomes extremely difficult and arbitrary. The issuing of alcohol cannot be governed on the basis of individual performance. The most real justification for imbibing is established simply by the individual's desire, and his ability to satisfy this desire in a socially acceptable fashion. This latter qualification can be determined only by the command.

Byrd

Health Problems

The summer (daylight) period had more outside activity, resulting in a greater physical fitness, good appetite with less risk of obesity, and sounder sleeping, but an increased susceptibility to trauma. Elevated temperatures in tunnels caused melting snow from the roof to drip on the tunnel floor where it formed icy lumps and created a threat of fracture and sprain. The winter (night) period, in contrast, resulted in poorer physical condition, decreased appetite, a tendency toward obesity, insomnia, and mental stagnation.

Incidence of Illness. It is of interest to note that no colds were seen in the wintering-over group, even after the arrival of infected relief personnel. However, the frequency and severity of some upper and lower respiratory infections in personnel after departure from the antarctic prompts speculation as to a causal relationship. A civilian, who went directly to new duty in Alaska, died suddenly of acute pulmonary edema following a few days of trivial upper respiratory symptoms. One case of Vincents angina occurred after eight months of close living. The case rapidly responded to penicillin. It is curious that this organism remained dormant for so long.

Climatic Effects. Upon arrival at the station, new personnel experienced a sensitivity to the cold and shortness of breath on mild physical exertion, which lessened with acclimatization. The face underwent the greatest degree of acclimatization, as it was relatively unprotected from the combined effects of wind and temperature. At first it readily showed the hard white patches of impending frostbite; later, much colder conditions and more prolonged exposure were required for the same result. Blizzard and storm conditions were capable of freezing snow, which had melted against the skin, and moisture from exhaled breath, to form a mass of ice enmeshing the face, beard, and nose. Under extreme conditions, tears on the eyelashes would freeze, binding the lids together.

In the latter half of October 1957, three persons wearing "Polaroid" sun goggles while working outside in overcast weather complained of severe frontal headache. A correlation with the azimuth of the sun at this time revealed its position to be 20 degrees, the reported threshold angle for ultra-violet penetration. This evidence, although incomplete, was diagnosed as snow blindness. All three cases subsided in 24 to 36 hours with a change to smoked-glass sunglasses.

No severe frostbite (third-degree) or general hydrothermia occurred. Minor frostbite became so common and so transient during outside operations that men frequently failed to report their cases. Face, ears, fingers, and toes were the only parts affected. Men so afflicted treated themselves by such simple methods as holding the part near the galley stove during the frequent coffee breaks.

Psychological Problems

Psychotherapy, whenever its need was detected, was administered informally over a cup of coffee. No sick call hours were kept. Personnel were encouraged to present themselves whenever the occasion arose.

An appreciable improvement in morale followed a liberal ration of medicinal alcohol at the midwinter party. However, the observer feels the tremendous value of alcohol in this situation was in inverse ratio to the frequency of such occasions.

Research

The monthly questionnaires in connection with the Little America dental research program received about 80 percent support. However, the BuMed psychological questionnaires met with less enthusiasm despite all the ingenuity used. The Gray Audiograph supplied for a similar program resulted in a solitary recording.

At the time of deployment to the antarctic available information (NAVMED 1307 p 194) warned against the use of epinephrine for cold-acclimatized individuals. This, however, was not substantiated by laboratory findings. At an isolated, cold-climate base, such as Byrd, the inability to use epinephrine to prolong local and regional anaesthesia imposes a serious handicap on the medical officer who is without a trained medical assistant. Accordingly, tests were made using minute amounts of epinephrine in volunteers selected among the most cold-acclimatized men at the base. The men worked for several hours daily in temperatures ranging from -20 F to -50 F. Doses ranged from 0.05 to 0.5 cc of 1:1000 epinephrine USP. The smaller doses made up to 0.5 cc, using saline as diluent. Measures were kept on hand following the injections to counteract any untoward effects, while blood pressure, pulse, pupils, and skin were continually observed in each of the subjects and recorded every five minutes for a half-hour period. With the 0.5-cc dose, minor side effects consisting of throbbing, palpitations, rise in systolic pressure, and dizziness on standing, were noted. However, these could normally be expected in temperate zones from such a dose. It was the observer's impression from this experiment that the very small amount required in local anaesthesia would not be expected to cause toxic or severe side effects sufficient to preclude its use.

Beardmore

The camp's isolation and infrequent visitation by outside personnel created a loneliness greater than that felt during the winter night at either Little America or McMurdo. Strong winds were frequent. All hands ate, worked and slept in one building. The group had no incidents of particular medical interest.

South Pole

Qualifications of Medical Personnel

In a small station, medical problems of any nature may be so rare that the station physician must have ancillary duties. Ideally, he should have an interest in another scientific project, such as physiology or even one of the geophysical disciplines. The matter of cold injury and its prevention is perhaps the only new item in the training of physicians for cold weather. A thorough knowledge of the principles of cold-weather clothing is desirable. The best overall training may come from reading the personal journals of previous explorers. The physician with post-graduate training in surgery would be the best qualified. The medical officer will probably be called upon to help keep the peace in the small station; with this in mind, he should be mature and have no personality problems which might make him a disadvantage rather than a supporting influence.

Climatic Effects

Fatigue. The altitude of approximately 9200 feet produced shortness of breath and easy fatiguing in all members of the party. Oxygen was provided for the party's use and was employed briefly in one instance of extreme fatigue. After seven to ten days, all hands noted gradual improvement in exercise tolerance, but even at the conclusion of the construction period, physical exertion was found to be much more tiring than at sea level.

Diet. Food and messing facilities were excellent in the construction camp, but in spite of this all members lost weight — estimated about 10 pounds per man, indicating the high caloric requirements of work under polar conditions.

Insomnia. Over half the personnel at the South Pole Station suffered from sleep disturbances of one kind or another. Five required intermittent sleeping medication. There was no apparent pattern to the sleeping problems, some having trouble in getting to sleep, others having trouble staying asleep. The only universal difficulty was in arising in the morning, and in this respect it was agreed that it was harder than in the States.

The fact that sleep came far more easily during the summer period for most individuals might mean either that exercise is vital or that keeping the mind occupied is vital, or a combination of both. It would seem important in any case to have better recreational facilities in the sports line for the long winter nights.

Dehydration. There was a general dehydration of the exposed parts, especially the skin of the dorsum of the hands. This phenomenon, which is thought to be part of the process of acclimatization as well as the low humidity, resulted in several secondary conditions. In three men, fissures or cracks occasionally appeared along the lines of the fingerprints, particularly at the edge of the nails. The fissures appeared spontaneously without incident trauma and involved the outer layers of epidermis only. Healing was often delayed, but the fissures were slight and no more than an inconvenience. The fact that the cook had this condition most frequently raises the question that detergents might deprive the skin of natural oils and precipitate fissure formation in the already dry skin.

It was also noted that minor wounds in the dry areas of the skin tended to heal far more slowly than usual. Often it appeared that the wound margins retracted, preventing approximation of the edges. There was never any erythema to suggest that inflammation or infection might be the cause of the delay, and so one must assume that the vascular changes involved in local acclimatization were responsible. This delayed healing was not observed in wounds of areas normally covered with warm clothing.

Cold Injury. The incidence of cold injury at the South Pole Station was extremely low. This may at first seem a paradox, since the temperatures at the Pole represent the lowest all-year-around average ever recorded. It should be kept in mind, however, that the mission of the station personnel involved primarily indoor work and that at no time were there extensive traverses. The duration of exposure to cold was therefore quite short on the whole, and a warm building was always within easy reach at all times.

The occurrence of arthralgias of varying degrees was universal. The occurrences were transient and followed work for prolonged periods in the cold. It was not uncommon for arthralgias or stiffness to be most annoying on arising in the morning if exposure had been prolonged the previous day. There was no effective treatment for this condition. Heat applied locally was of considerable value temporarily; but the condition was self-limited, and pains tended to disappear with exercise, so that any therapy was hard to evaluate.

The most common chest problem was a cough with slight hemoptysis, which occurred in almost all hands at various times during the year. In general, the cough was apparently the result of deep breathing of cold air and followed work by a few minutes to one hour. The coughing, which was usually unproductive, would not occur after normal breathing even in the coldest temperatures. Deep breathing was required. Hemoptysis was always very mild and transient.

Another disorder which may be taken as a direct result of the cold is the increased incidence of nosebleeds during or just following heavy work outdoors. A proper face mask may be the answer to this troublesome condition.

Frostbite. Unlike the situation at the coastal stations, the sun did not have sufficient warming effect at the South Pole to enable men to work outside during the summer without total body covering. The face was generally the only exposed part, and the nose was most vulnerable. The symptoms of a frozen nose might develop very rapidly. The entire duration of symptoms may be only a fraction of a minute; and at times there would be no symptoms whatever. Ears and hands seem the next most frequently affected, although the malar regions of a few men froze virtually as often as their noses. There was no frostbite of the feet.

The treatment for first-degree frostbite was self-administered in all cases. Warming the part with the bare hand (or with the abdomen, in the case of the hand itself) would rectify the situation in a matter of a minute or two, after which the individual would proceed with his activities. On cold windy days on the windward side of the base, a man might freeze parts of his face a half dozen times in a single afternoon. The event was regarded as a nuisance but certainly not as an excuse to

quit work or take a break. First-degree frostbite was so frequent and so transient that the men seldom reported it, and no accurate record of frequency could be obtained. An estimate of once per man per day would probably be on the low side for certain days during the summer work periods.

There were only two cases of second-degree frostbite. One occurred on the cheeks of a man wearing sunglasses with metal rins. The second case occurred on the hand of a man working outside in midwinter.

Snow Blindness. There was no snow blindness at the South Pole Station. The reason for this is not obvious because the Polar Plateau presents as great an expanse of unbroken snow as possible, stretching as it does from horizon to horizon. The personnel were not particularly careful in wearing sunglasses, however, and a few men seldom wore them at all. Most of the outside work was done either in the drop zone or work areas, both of which were thoroughly littered with dark objects such as crates, parachutes, and packing materials while the sun was high overhead. It is recognized that if even a small part of the visual field is darkened, the susceptibility to snow blindness is greatly diminished. Hence the presence of a clutter of building equipment and supplies may have had a favorable effect.

It has often been noted that snow blindness appears more frequently in cloudy weather when the sky is also white or light gray. The South Pole summer was very mild and blue skies were the rule. Furthermore, the sun never rises above 26 degrees, so shadows are always present. Both these factors may have been decidedly an advantage in reducing snow blindness.

Prevention of Cold Injury. In the prevention of cold injury, the most important factor is probably experience. Frostbite is painful, and the men who have had it even in minor degrees come to realize this and take measures to avoid it, which is far more effective than any lectures or book reading could be. At the South Pole we are not faced with the slow creeping cold which is responsible for so much cold injury in other environments, but rather with a brisk cold which attacks fiercely and rapidly. The low humidity apparently decreases the sensibility to the cold right up to the point when frostbite is imminent.

"Cold" in the sense of the sensation one gets when stepping into a shower of cold water (i.e., common usage) is certainly felt here as well as any other environment. "Cold" in a new sense of the word, however, is felt in the exposed parts, and is more like a sensation of heat that cold. The sensation is duplicated closely by pouring ethyl chloride on the skin and blowing the spot to evaporate it. Another indescribable attribute of the South Pole coldness is the apparent lessening of the "unpleasantness" of the sensation. Whether this is due to acclimatization in

the low humidities, or some other factor, is difficult to say. The unpleasantness of the cold here is the feeling that a part of the body is close to that borderline of freezing which becomes so well known and so dreaded. It is the progressive stiffness of the fingers, or the aches and pains which are attendant on any prolonged exposure.

One should dress for the wind rather than for the temperature at the South Pole. One may feel colder on a warm windy day than on a calm day twenty degrees colder by the thermometer. An accidental death from exposure with the classical pattern of fatigue, drowsiness, and warmth would probably be impossible at the Pole, since this pattern requires a slow cooling of the body temperature. The transition from normal body temperature to lower temperatures at the Pole would take place rapidly, causing intense shivering and agitation rather than drowsiness. Although this is perhaps in our favor, it should be emphasized that the present clothing is inadequate in itself to protect a man indefinitely from winter temperatures. An outside source of heat is necessary.

Screening of Personnel

All men who were proposed as members of the construction party were examined physically by the medical officer at McMurdo. All those who had complaints which might interfere in any way with strenuous physical exertion were disqualified. Personnel were questioned particularly in regard to musculo-skeletal and respiratory disorders. Hemoglobin determination was performed on each man to make sure no one with anemia was sent to the high altitude of the Pole.

Alcoholic Beverages

The advantages of having alcohol in a small isolated base are numerous. First of all, it must be remembered that the personnel of the small base are deprived of many comforts and pleasures normally found in even the most distant parts of the world. These things combine to make the men feel restricted as well as isolated, so that every possible privilege must be used to offset this feeling. Although the use of alcohol may not be condoned in regular duty, in isolated duty it actually is small compensation for the freedom lost in other ways.

Secondly, alcohol is most important in adding variety to the weekly routine. It is hard to express how vital "variety" is in the maintenance of good morale. Alcohol serves this purpose well. Furthermore, the actual taste of the drink is a welcome addition to a diet of monotonous dehydrated and canned foods, and it is excellent in increasing appetites.

Finally, alcohol fills a most significant function in maintaining a harmonious, well-knit group. When alcohol is served to the group during a "happy hour," much of the unpleasantness of living in confinement with so few others disappears. All the petty grievances, grumbles, and differences of opinion are melted away. Nonetheless, it would be unrealistic to look on alcohol as a panacea.

Alcohol has its disadvantages. One worries about outright drunkenness with all the dangers that this implies. Another disadvantage is that alcohol, when fairly distributed to all hands, may be used as a barter item by the nondrinker, creating a blackmarket and therefore bad feelings and trouble. Finally, one may say that, because of the hardships of isolated duty, the presence of alcohol might be seized upon too avidly, with the creation of frank alcoholism and chronic disability in a few men.

These problems were recognized at the South Pole Station, and the policy was so directed to gain the most from the supply of alcohol and at the same time minimize its dangers. From the start, alcohol was distributed only on Saturday nights. Whiskey and brandy were both available, and no restriction was placed on the quantity taken during the "happy hour." It was made clear, however, that any man who abused the privilege would be denied further alcohol and that if any injury occurred as the result of alcohol, the supply would be stopped for the remainder of the winter night. It was not these threats which kept the men in bounds so much as it was the social pressure of the small group. In a station of only eighteen men, nothing goes by unnoticed, and the group can exert a great deal of force by even a casual disapproval.

The problem of alcohol being used for barter did occur, with the 2-ounce bottles of brandy. This was rapidly remedied by serving the brandy out of a quart bottle and keeping the small bottles secured. After this change of policy, there was no more trouble in this respect.

In summary, alcohol found good use at the South Pole Station. It was not used in excessive amounts (4 to 6 ounces per man per month). It was welcomed during the group occasions for its taste as well as its warmth. It tended to bring the men together. Those minor problems which arose because of its use were easily handled by judicious distribution of the supplies.

The one recommendation is the opinion of the entire station personnel. It is that it would be far wiser to supply a larger variety of better grade alcohol in small quantity than huge supplies of second-rate materials. The men do not use the alcohol for effect. The morale value lies elsewhere.

Research

Urinalysis Study. Routine urinalysis was performed on specimens from sixteen of the South Pole personnel to ascertain a rough gauge of "normalcy" and perhaps to assist the future physician here who is faced with the problem of not knowing normal ranges in acclimatized personnel. None of the men were on the sick list at the time of the study. There appeared nothing unusual about the color of the urines. They were mainly medium yellow. Cloudiness of the urines frequently appeared: clear, 50 percent; slightly cloudy, 25 percent; grossly cloudy, 25 percent. The pH ranged from 5.5 to 6.0 70 percent of the time. The specific gravity ranged from 1.090 to 1.031. No glucose and albumin were found. Microscopic tests revealed leukocytes 100 percent; epithelial cells, 25 percent; amorphous matter, 45 percent; mucus, 25 percent; and crystals, 30 percent. The cloudiness of the urines was due either to amorphous ureates or phosphates. All urine specimens were random specimens. The pH determination was with Nitrazaine Paper; the glucose determination was with "Urine-Surgar Test Tablets"; and the albumin determination was by heating in an acid medium.

Blood Studies. Routine blood studies were done on four of the South Pole personnel who were not on the sick list. Studies included complete blood counts, venous clotting times, erythrocyte sedimentation rates, hemoglobin determination, clot retraction times, and specific gravity determinations on whole blood and plasma. The results indicated that all values were within the predicted limits of "normal." No effects of high altitude were noted in the blood counts. RBC ranged from 5.5 to 6.5 million. Hemoglobins tended to the high side of normal sea-level range. ESR was consistently 1 to 2 mm. Specific gravity determinations are thought to be too unreliable to be reported. VCT again presented the curious phenomenon of being greatly prolonged in a few isolated cases. No cause for this is known, but the technique (Lee-White) may have been at fault. Calculation of MCH, MCHC, and MCV showed values within the normal range for all subjects tested.

Hallett

Medical Facilities

At the beginning of the operation at Hallett, the medical officer was dependent on the ships' medical facilities. Only immediate emergency and minor treatment was done at the camp site. The medical facilities consisted of an emergency medical kit prepared by the medical officer. The permanent base was occupied early in January 1957. At this time all perishable medical equipment was uncrated and moved into the sick bay. Operating table and lights were set up. A spare 55-gallon fuel drum was used as water supply. A temporary sink was made out of a large cooking

pot, but was later replaced by a large darkroom sink. Provisions were not made for heating water in the sick bay.

Responsibilities of Medical Officer

During the construction period the medical officer was responsible for the water supply in addition to his medical duties. He assumed duties as officer-in-charge at Hallett Station in February 1957 and was responsible for the supervision of all departments. He shared cleaning and water details with the group, and served as storekeeper. During flying operations he was in charge of the crash crew and was responsible for checking conditions of the ice runway. It can readily be understood that difficulties can be encountered when a medical officer has to serve in several capacities.

Health Problems

Diseases and Illnesses. During the construction period injuries were seen very frequently. These were usually minor and most were on the hands. At that time, no major injuries or infections occurred. During the isolation period there were frequent complaints of sore throats and nosebleeds. These were probably caused by the low humidity, and very little could be done to prevent them. Two cases of middle-ear infection were treated; these were secondary to the sore throat. There were no hospital cases, and very few man-hours were lost due to illness. Due to the small number of persons at this station, sick call was held at random. Individuals reported to the medical officer whenever they had medical complaints. Unusual illnesses did not occur at this station.

Climatic Effects. Cold weather will hinder an individual's health if he is exposed to it without due precautions. A person doing heavy work without the necessary clothing is more apt to get hurt; muscles will get stiff and inefficient. In this kind of environment one has to be more careful in the quality of his diet. He should take vitamin pills because even though foods are kept frozen, their vitamin content, especially vitamin C, will decrease as time passes. Infestious diseases were seldom seen. Apparently there is a decreased quantity of bacteria because of the low temperature.

Acclimatization of the face and hands was very fast. It took a longer time for the body to get used to low temperatures, and heavy clothing was worn for a while. As soon as the body got used to the low temperature, individuals wore lighter clothing. The temperature indoors was kept at 68 F, which felt cold the first few months until individuals got used to it.

Frostbite was seen on three occasions, but two or three weeks had passed before the patients noticed any change and reported to sick bay. These were first-degree cases and involved less than one square centimeter. There were no cases of snow blindness.

Psychological Problems

At one time or another everyone went through a period of depression. At such times they wanted to be left alone. This never lasted more than a few days. It was noted that some individuals sought attention from others. There were a few chronic complainers. At no time were tranquilizers used for the treatment of these neurotic manifestations. In general, the manifestations were mild, but because of the size of the group, these were heard over and over again, making them more noticeable.

Alcoholic Beverages

Alcohol on hand at Hallett consisted of whiskey, brandy, and 95 percent grain alcohol. Only one-third of the stock was expended from January 1957 until January 1958. Beer was sold at the ship's store and was bought at a rate of one case per man per week. Drinking was allowed after working hours only. This was followed by everyone. No restriction was made on the amount each man could drink, but they were cautioned against drinking too heavily to prevent interference with their work the next day.

Wilkes

Medical Facilities

During the off-loading and construction period, a first-aid station was set up in a corner of the radio and administration Jamesway for care of minor medical problems of the approximately 100 workers and for direction of evacuation of serious casualties. Following commissioning of the Base in February 1957, the task group departed, leaving the wintering-over party of 10 civilian scientists and 17 Navy personnel to finish construction and settle down. At this time the Wilkes medical department consisted of thirty-odd crates of medical supplies, and slightly over 300 square feet of newly tiled but otherwise unimproved space in a 48-foot by 20-foot Clements hut.

Medical Personnel

During the construction period, two corpsmen alternated on 12-hour shifts. The wintering-over physician also lived ashore to supervise the station and was on

24-hour call. During the period of isolation the medical staff consisted only of the physician.

Health Problems

There were no serious medical problems during the two weeks of off-loading and construction. The two cases evacuated to ships were a simple, undisplaced finger fracture and a man showing asthenia, lethargy, questionable icterus, and palpably enlarged, tender liver in which a diagnosis of incipient infectious hepatitus was thought likely. With the temperature varying between 20 F and 45 F there were no cold injuries whatsoever.

Injury. One man, admitted to the sick list at Wilkes, fell approximately 4 feet from a D4 tractor superstructure, striking his left shin on a projecting metal part. When first seen in sick bay it was noted that, though neither trousers nor long underdrawers were torn, there was a deep grossly contused, triangular laceration. Twenty-four days after original laceration, the patient reported pain and swelling at the wound site following a severe blow to the area 6 to 8 hours earlier. Inflammation subsided and wound healing progressed well until discharged to full duty eight days after admission. This slow healing and tendency to infection was due to the cold climate.

Asphyxia. A potential hazard of cold-weather living was illustrated by the mechanic who had spent the afternoon welding galvanized metal and had not opened the garage doors to insure adequate ventilation because of the sub-zero cold. This man was given a diagnosis of acute metal fume (zinc) poisoning and put to bed. Thirty-six hours later he felt entirely well.

The one case encountered of carbon monoxide poisoning was minor and resulted when a man continued to drive a weasel even though he was aware that exhaust fumes were entering the cab through an eroded exhaust pipe.

It should be pointed out that in cold weather trail work, especially when a party is caught in a blizzard, men often sleep in weasels because of their warmth and the trouble of setting up tents in a wind. Under these circumstances the vehicles are usually allowed to run all night because of the likelihood of their not restarting at low temperatures. The possibility of a small exhaust leak into the weasel cab could be a real hazard under these conditions.

Climatic Effects

In most respects weather had no particular bearing on the type of case seen at sick call at Wilkes Station. The absence of upper respiratory infections was noted.

One condition noted at Wilkes, and apparently also at other U. S. bases, was that superficial wounds healed slowly and tended to become infected. At least this was the case during the first two months of wintering-over. During this time, also, several other interesting inflammatory conditions of subcutaneous tissues all disappeared with application of local heat for seven to ten days. During midwinter, presumably after acclimatization, wounds healed readily without infection and no further unusual inflammatory lesions were seen.

Acclimatization. The only actual cold injuries sustained by Wilkes personnel were those resulting from work and travel on the ice cap and were seen at the main base only in convalescent state, if at all. These included several instances of first and second degree frostbite. It is certainly true that in February and March, when wounds healed slowly, men still felt cold in the 20 to 30 F temperatures and had not yet been convinced to keep their barracks thermostat at 65 F or below. It is also true that some acclimatization did occur, for after early April (when, incidentally, healing began to proceed normally) men actually began to shed clothing, although the weather grew colder, and during the winter complained of sweltering heat when the galley temperature occasionally reached 80 F.

That this was far from complete acclimatization is indicated by the conditioning of the glaciologists, who spent the winter in the icecap station Jamesway hut. Here the temperature which never rose above freezing at the floor level, was approximately 35 to 40 F at the 1-1/2 foot level of the cots, was 55 to 60 F at the top of the hut, occasionally went to 70 F at the hut roof directly over the space heater. Visitors to the station huddled in heavy clothing while the glaciologists sat comfortably in shirt sleeves (though they retained well-insulated foot gear). When the glaciologists returned to base, they complained of the heat in the barracks in which eye-level thermostats were set at 65 F.

Dehydration. An interesting case illustrating an unusual hazard of cold-weather living occurred in late May. Questioning disclosed that the patient had been spending most of his time away from the base on fieldwork, subsisting primarily on tea and chocolate bars (two of the primary sources of oxylates), and had been thirsty most of the time. The patient was taken off these foods and the diagnosis was considered to be oxylate crystalluria. This would seem to point out a potential hazard accompanying the dehydration and tendency to subsist on tea and chocolate so often encountered in people doing strenuous trail work in cold climates.

Psychological Problems

This, eventually and discouragingly, is probably the most important factor of all which influences morale. Men with neuroses, particularly character neuroses, find group participation on a natural basis difficult and are likely to be unhappy and make others unhappy.

Alcoholic Beverages

Wilkes was lucky to have an abundant supply of liquor. Our original stock of whiskey was increased by liquor left by MCB ONE. Whiskey was served on an ad-lib basis at routine Saturday night and holiday evening parties. On special occasions, fairly potent fruit juice punches were concocted with varying ingredients and were much appreciated.

The original stock of 2-ounce bottles of brandy were also increased by those left by MCB ONE. This enabled routine after-work rations throughout the year. This 2 ounces of liquor at the end of the day tended to promote relaxation and sociability when all personnel gathered for the evening meal.

Beer was supplied as a ship's store item in large quantity and was much used. The anxiety-relieving and socializing values of alcohol are well known and were well utilized at Wilkes. There were cases of intoxication, but as alcohol was available only during off-duty hours, no difficulties arose. It was felt by most that morale was enormously aided by our adequate liquor supply.

Research

There was some interest in the adrenalin sensitivity debunking experiments carried on at Byrd Station. Although these studies were not done officially at Wilkes, one of the glaciologists was sufficiently interested to suggest shots before and after his stay at the icecap station. This 190-pound man showed no appreciable response to 0.25 cc and only minimal pulse and blood pressure response, with no subjective reaction at all, to 0.5 cc of 1.1000 adrenalin before leaving. On return from two months on the icecap he showed precisely the same reactions. It would therefore seem that adrenalin sensitivity, if it exists at all, is certainly not the rule with the degree of acclimatization encountered at U. S. bases. Nor does it seem reasonable that sensitivity to a vaso-constrictive drug should play a major part in a process that actually consists mainly of peripheral and superficial vasodilation.

Ellsworth

Medical Facilities

One of the temporary Jamesways was set aside for use as a first-aid station. Two large medical chests containing emergency medical and surgical supplies were moved from the ship to this building. Minor injuries and complaints were handled

in this first-aid station. More severe injuries or those cases requiring bed rest were sent back to the ships for treatment. When the last ship had left in February 1957 the interior construction of the permanent sick bay was still incomplete and none of the medical supplies had been unpacked. It was approximately two weeks before the permanent sick bay was in operating order and the medical supplies unpackaged. At that time the temporary first-aid station was closed, but some medical and surgical supplies were left there as a precautionary measure in case the permanent sick bay should be destroyed.

Medical Personnel

The medical personnel at Ellsworth consisted of a doctor and a corpsman. One of the civilian personnel had been a male nurse, and offered his services if needed.

Medical Instruction and Assistance

During the winter months, the scientists scheduled to go on the summer traverse were invited weekly to listen to informal talks on first-aid and demonstrations given by the medical officer. These were well attended. Before their departure, the scientists were supplied with two small medical chests with all the medicines and surgical instruments that they were capable of using. On several occasions medical care in the form of drugs or a surgical procedure was given to the British personnel at Shackleton and Halley Bay stations.

Health Problems

Incidence of Illness. Although there were regular sick-call hours, these were rarely adhered to and people visited the sick bay whenever they had the urge to do so. The health of the personnel at this station was very good. There were no cases of communicable disease. Infections were a rarity. Infections requiring antibiotic therapy were one urinary tract, several tonsilar, and lacerated wounds. No "colds" nor upper respiratory infections were treated. Dryness and crusting of the nasal passages was a common finding on examination and was complained of by a few. This was probably due to the dryness of the air within the buildings, where the relative humidity averaged between 30 and 35 percent.

Injury. The number of sprains, particularly of the ankle joint, was out of proportion to the number of other injuries seen. This preponderance of ankle sprains was due to the slippery condition of the walkways in the tunnels. Placing of duckboards in the tunnels helped to correct the situation, but sand or some other material would have been useful.

Dermatosis. Dermatologic problems were rare except for a few notable exceptions. One aviation mechanic who had first contacted a fungus infection of the hands and feet about six years previously while in the South Pacific, and had periodically been troubled since, had a flare-up while in the antarctic. He had pruritus and vesicles on his hands and feet. Local treatment of the condition was only palative and it recurred when not treated. The other skin lesion that did not disappear while we were on the ice occurred on the hands of the senior cook. It was diagnosed as an atopic dermatitis believed to be due to flour.

Diet. Most of the men gained weight the whole time they were in the antarctic. A few, who had gained from 15 to 30 pounds, voluntarily put themselves on restrictive diets. The general gain in weight was probably due to the regular hours and the good meals and snacks which were available throughout the day and night.

Surgery. Elective surgery was in all cases deferred until the individual could have it done in the U.S.A.

Climatic Effects

Frostbite. During the entire year there were about ten cases of frostbite seen in sick bay. The majority of these were first degree and only a few were considered second degree due to the presence of blisters. All cases of frostbite were of the face, with the exception of two cases involving the hands. The ears were affected most often and the nose and cheeks in fewer instances. In most cases the injury could have been prevented if sufficient clothing had been worn and a few preventive measures taken. No one was incapacitated because of frostbite.

Arthralgias. Of much greater importance than frostbite was the problem of arthralgias due to cold and muscular and ligamentous injuries. Some of the personnel regularly working outdoors during the whole year had recurring bouts of arthralgia lasting from several days to a week or more with symptomless periods between. In decreasing order, the joints most often affected were the elbows, knees, fingers, and shoulders. The usual complaint was "aching joints." Signs of joint involvement were minimal or absent. The application of heat to the involved joint by means of a chemical heating pad and oral administration of aspirin was the routine treatment. When possible, the man was also taken off outside and heavy work. Even on this regimen, symptoms would usually persist for four or more days. It is believed that these cases of arthralgia seen in the antarctic were due to the cold, as they did not occur in personnel who regularly worked indoors. During the period of base construction two cases of traumatic arthritis of the knees were seen. Both men complained of pain in their knees. One man said his knees also "buckled up" while walking and he had a considerable limp. The men had a very slight amount of swelling about

both knee joints, but no other signs. Wrapping the knees with an elastic bandage did not help the condition any. After four days, one of the men was placed on bed rest. The condition improved but reappeared several days after he started ambulating. When men are on ships enroute to similar operations they should get daily exercise, and once they are on the beach the work load should be increased progressively.

Snow Blindness. No cases of snow blindness were reported at Ellsworth. Most personnel consistently wore some type of dark glasses when outdoors. One driver who worked outside much of the time regularly complained of frontal headaches, which were relived by aspirin. He always wore dark glasses and his vision was good whenever checked. One of the civilian members of the traverse party usually did not wear glasses even in the summertime, but did not complain of headaches or eye trouble.

Insomnia. Complaints of insomnia were most prevalent during the months of March, April, and May. There were two environmental changes taking place at that time. The winter darkness was setting in and the amount of hard outside work was ending. In only three or four cases were the symptoms considered severe enough to warrant the use of barbituates. After the month of May and including the summer months of 1958, the complaint was very sporadic and affected only a few individuals.

Screening of Personnel

The psychiatric program that was used to screen wintering-over personnel left much to be desired. Too much emphasis was placed on motivation and not enough direct observation of how individuals reacted within the group while at Davisville. More importance should be placed on how an individual's personality and his behavior fits into the unit as a whole. This does not mean that some psychiatric screening in the initial process of selection would not be valuable. The people that are going to a particular station should be placed in a separate unit and the final selection be made the responsibility of the officer-in-charge of a station, along with the help of the other officers. It is equally as important to know if a man has a congenial personality, if he is able to orient himself to the group's goal, if he feels he is a part of the group, if he can obey orders willingly, if he knows his job, and if he is a willing worker.

All personnel at the station were again examined in July of 1957 after being in the antarctic for six months. The findings of this examination were entered in health records, and individuals needing dental or medical treatment were given appointments.

Research

The psychiatric program as set up by the Bureau of Medicine and Surgery failed to make use to the fullest extent of the medical officers at the individual stations who had a personal interest in the program and close association with the personnel. The multiple-test sheets were loaded with emotionally disturbing questions that in most instances were either not answered truthfully or left blank. It is believed, in the interest of morale, that these tests should not be given to people while they are living in isolated spots.

Almost any type of research was impractical during Deep Freeze II at Ellsworth Station. Insufficient time after routine duties had been done prevented the medical officer or any other personnel from taking part in research projects. However, now that the station is established, and provided the medical officer is not kept busy with other than medical duties, it would seem possible that he could carry on some limited studies of cold acclimatization or some investigation that would take advantage of the location. While it would not be possible for the station doctor to go himself, he nevertheless could probably help in research carried out by ornithologists at the newly discovered Emperor penguin rookery at Gould Bay.

Alcoholic Beverages

A two-year supply of brandy and bourbon and several cases of rye and sherry wine were kept outside in security lockers the entire year. Although freezing took place, none of the bottles broke or lost their contents. During the building period two ounces of brandy was given to everyone in the summer support and wintering-over groups when they had finished working a shift. Almost everyone took their ration and it was obviously a morale booster. During the remainder of the year liquor was consumed principally during station parties, which were thrown every two or three weeks. Very little liquor was used for medicinal purposes.

Since most liquor was used for social drinking, it would serve its purpose better if there was a selection large enough to make mixed drinks. Some gin, vermouth, Scotch, and a greater selection of wines should be included.

DENTAL HISTORY

McMurdo

Dental Officer

The original plan for Operation Deep Freeze I made no provision for a dental

officer at either of the two wintering sites. Later the plan was changed, and a dental officer was assigned to McMurdo Sound.

At the U.S. Naval Medical Research Laboratory, New London, Connecticut, the dental officer scheduled to winter over at McMurdo had been provided with an excellent program of oral research, to be carried out during his stay in the far south during Deep Freeze I. As the operation developed, however, it soon became apparent that such definite laboratory investigation would have to be deferred until the operation's pioneer first-year phase had passed. The dental officer found that a considerable amount of nondental duty, added to the clinical work, fully consumed his time. It was the first time that a dentist had wintered in Antarctica.

Dental Cases (Deep Freeze I)

Of the 92 possible dental patients in the wintering party, there were but three who did not receive treatment during the course of their stay at McMurdo. As is usually true in dental practice, most of the clinical procedures carried out were designed to keep pain from arising, rather than to alleviate pain already present. Several cases disclosed tooth pain resulting from lack of proper insulation beneath metallic restorations. The restorations had been placed at previous duty stations. They had been entirely comfortable until the men went to Antarctica. When exposed to the cold air of the antarctic, the teeth became painful. Permanent amalgan restorations, with sedative-base linings were made in all cases. No further recurrences of pain were reported, except by a patient who was later assigned to the South Pole construction party. About an hour after landing at the South Pole, two teeth began to hurt slightly. No medication was given to relieve the discomfort; it left in a few hours and never returned. The explanation for this phenomenon seems to be the very abrupt change in atmospheric pressure when, in the course of a few hours, the patient was transported from the sea-level altitude of McMurdo Sound to the 10,000-foot altitude of the South Pole.

Hypersensitive cervical dentin was a common complaint. Relief was usually realized from the application of silver nitrate or trichloracetic acid. If such conservative measures failed, a cavity was prepared and a filling inserted. There was only a small amount of periodental trouble to be treated by the dental officer. Gingival disorders usually responded to scaling and polishing of the teeth and the use of hydrogen-peroxide solution. Pericornitis was treated successfully with iodoglycerol (or with extraction) in the usual manner. In four instances, abscesses at the apices of anterior teeth were eliminated by root-canal therapy and apicoectomy. Several canker sores were acuterized with trichloracetic acid. The dental officer did not notice evidence of vitamin deficiency in even a single instance. The medical officer concurred in this observation.

One unusual periodontal case illustrated the effect on oral soft tissues of tension, fatigue, and strain. The patient had a canker sore on the left side of the lower lip, and very sore and bleeding gums. He had been taking his daily vitamin tablet. The dental officer learned that the man had been under considerable tension and fatigue for several days before and that his mouth in that time had become progressively more uncomfortable.

The dental officer was impressed by the quality of mouth hygiene practiced by the McMurdo wintering group. It was a reflection of the good camp living standard provided by the Navy, and also a reflection of the good leadership in camp. There were a number of old fillings which came out of their cavities, but in nearly every instance the dental officer could see an obvious cause; usually the filling was simply undermined by decay.

In the course of the stay at the McMurdo Sound camp the dental officer did eight denture repairs; one appliance was a full denture and the other seven were partial dentures. In three of the eight cases the complaint was that the denture had broken while the patient was eating. In these cases it is conceivable that there was some cold-weather cause for breakage. The obvious cause was usually direct trauma.

Because of Frazier's report, observations were made in the matter of syncope following anesthetic injection. Some 250 cartridges (1.8 cc each) of 2-percent lidocaine hydrochloride solution, containing epinephrine (adrenalin) in the concentration 1-to-50,000, were used at McMurdo. From this there resulted only two cases of syncope. Both occurred at morning appointments and to patients who had eaten no breakfast before reporting at the dental office. The first patient was quite ill for about ten minutes, the other for about 20 minutes. Both received the same anesthetic solution at subsequent sittings and experienced no untoward effects. Very probably the percentage of syncope reactions following injection of this standard-type epinephrine-containing anesthetic solution was no higher at the McMurdo Sound wintering camp than it would have been at a Navy installation in the United States.

Conclusions. 1. Several cases showed tooth pain resulting from lack of proper insulation beneath metallic restorations.

2. Hypersensitive dentin was a common complaint.

3. There was only a small amount of periodental trouble at the camp.

4. Only two cases were observed of syncope following anesthetic injection.

5. The quality of mouth-hygiene practice was found to be good.

6. No evidence of vitamin deficiency was detected by either dental officer or medical officer.

Dental Cases (Deep Freeze II)

Dental officers of Deep Freeze II observed no inexplicable dental experiences. Teeth were necessarily extracted; however, "shattering" of teeth and unusual fracturing of restorations and teeth were not encountered. Prosthetic fractures occurred but appeared related to the basic principles of stress and function in appliances.

Conclusion. It is the opinion of the dental officers of Deep Freeze II that dental experiences in the antarctic are similar to those encountered in any cold-weather climate, but that extended isolation and constancy of cold increase and magnify these dental experiences.

Dental Requirements

Personnel. A dental officer's presence during a prolonged expedition to an isolated, unnatural environment such as the antarctic is essential for the health and welfare of the men and for the satisfactory completion of the expedition assignment. It can be readily understood that the elimination of dental pain is an important factor in the completion of a man's assigned duties; however, of greater importance is the routine care particularly essential in the antarctic where general hygiene and oral hygiene facilities are a problem rather than the customary convenience.

Seventy-five days of the year during Deep Freeze II the dental officer served as OOD. The injury of two officers necessarily increased the work load of all personnel. During the summer months at McMurdo when the base population rose at one time to 400 the volume of work necessarily increased. Men destined to winter over at isolated bases who had not been completed at Davisville, R.i., and men leaving the ice after a year's duty made up the majority of requests for dental services. The demand for services at no time reached that necessary for the assignment of a second dental officer to the base for the summer months. Present facilities available also preclude the maximum utilization of two dentists.

Preparation of Personnel Prior to Departure. Preparation of personnel departing for isolated duty regardless of the presence of a dentist at the proposed base is of utmost importance. Men assigned to bases who do not have a dental officer must be totally complete prior to departure for the ice. Men who will have dental services available to them must be routed through the clinic prior to departure to insure the

dental suitability of all expedition members. A dental officer who is aware of the facilities available in the antarctic must be assigned in the early stages of the operation. He should examine and supervise the care of all expedition members. Standards for civilian and military personnel must be the same.

The routing of both summering and wintering personnel through the clinic is essential for the maximum efficiency of the dental department in its support of the operation. The referral from the Ice of one or two men who have been trained for the operation can jeopardize the completion of assignments. To do justice to the pre-antarctic care of the men in an operation as large as Deep Freeze II will require the assignment of several dental officers to the dental clinic and the full cooperation of the dental staffs to whom patients may be referred. Therefore, prior to assignment of a man for specialized training he must be dentally qualified.

If the man is scheduled for isolated duty for one year without the care of a dental officer, he must be totally complete. If he is assigned to isolated duty without the services of a dental officer for six months, he must be essentially complete. If the dental officer is available for care, the requirements should be the same as those for submarine duty.

The early assignment of the dental officer is necessary not only to insure the completion of the dental care of the men, but to give the dentist time for necessary additional training. Courses in anesthesiology and survival training are strongly recommended for the wintering-over dentist.

It is estimated that 90 percent of the men scheduled to winter over at isolated bases were essentially completed at Davisville prior to departure for the ice. Substitutions and rescheduling of men account for the 10 percent who were not completed. Men were considered complete when all areas where decay had invaded the dentin were restored, when inflammatory processes in the soft tissues had been stopped, and after instructions in oral hygiene had been given. In addition, each patient was given a general idea of types of dental pain that he might encounter and the probable prognoses.

Clinical Recommendations. It is strongly recommended that a portable dental clinic be considered for future expeditions to the antarctic. A portable clinic similar to the mobile units available could be designed and equipped in Davisville with much more efficiency than establishing a dental clinic in the antarctic. The necessary supplies could be shipped in its interior. Heating and insulation would offer no problems. Properly outfitted, this type of clinic could serve a temporary base quickly and adequately and still be available for use at the termination of the temporary base.

Research

Antarctic duty for naval dental personnel offers dental research opportunities. Nutritional, thermal, isolational, and psychological stresses and their effect upon the teeth and associated structures may be studied. Research endeavors will be realized upon the analyzation of data and the application of findings to aid in future expedition planning.

Little America

A dental officer was not assigned to Little America during Deep Freeze I. Dental problems which occurred during the wintering-over period were treated by the medical department. All wintering-over personnel had dental examinations prior to departing for the antarctic, but, unfortunately, many of the men did not have their dental work complete prior to sailing.

Extractions were performed only when toothache became severe and interfered seriously with the patient's comfort. In two cases temporary fillings were attempted where old fillings had been lost. One filling remained in place for six days; the other remained for three months until removed by a dental officer at the time of definitive treatment. This was in November 1956, when the VX-6 Squadron dental officer visited Little America, which was the first opportunity many of the men had had in over a year to have serious dental disorders treated.

At Little America Station, a dental research program, part of the collateral duty of the dental officer, accounted for the major difference in total procedures of Little America and McMurdo dental facilities. Patients were routed through the clinic each month.

Byrd

Personnel were examined by the Little America dental officer in October 1957. Periodental treatments were given to members of the traverse party. The medical officer stated that a total of three dental cases were treated during the year. Equipment was felt to be adequate for any dental emergency that the medical officer would treat.

South Pole

The medical officer stated that there were essentially no dental problems. One temporary filling was lost. Only passing discomfort was felt by the cold. Equipment appeared to be adequate. He strongly recommended the complete dental workup of

all personnel prior to departure to the ice. He felt there was no need for a protective appliance for the teeth. All of the Pole Station personnel (exclusive of the civilian personnel) were essentially completed dentally at Davisville before departure.

To the corpsmen attached to the construction group during Deep Freeze I, fell the distinction of being the first men in history to extract a tooth at that remote location. The necessity arose when one of the men was accidentally hit in the mouth during the camp construction effort.

Hallett

Three temporary restorations were inserted by the medical officer. Several dental complaints were voiced; however, there was no emergency requiring the extraction of teeth. Dental equipment was considered adequate for emergency use by the medical officer. Dental facilities consisted of a bare minimum of equipment. Hand instruments were used.

Wilkes

Twelve patients were treated during the year, mainly for cavities and cracked or lost fillings.

Ellsworth

The medical officer stated that there were several extractions performed on men enroute to the ice by one of the dentists on an icebreaker. Sick calls throughout the year for dental problems were light. The biggest dental problem appeared to be cold sensitivity in the anterior part of the mouth. All of these cases appeared to be related to gingival abrasions or recession. He placed twelve temporary fillings in fractured restorations. He had several complaints of toothaches after flying. Several of the men complained of "gum problems." Gums were described as "boggy or tender." He felt that the equipment for emergency use was adequate.

It is the opinion of the dental officers that the infrequency of dental complaints at these isolated bases was due to the dental preparation of the men at Davisville prior to their departure for the antarctic.

Summary and Recommendations

1. Ninety-seven percent of all personnel wintering at Little America and McMurdo were treated by the dental officers. A dental officer's presence in the antarctic at bases as large as McMurdo is essential.

2. The preparation of all personnel prior to departure for the antarctic is essential. The assignment of several dental officers to the clinic preparing the men for departure may be necessary.

3. Dental qualifications must be established and met for all personnel departing for the ice and prior to specialized training of the men.

4. Dental officers must be trained in anesthesiology and survival training. If dental officers are to be assigned collateral duties, special training in the field of duty should be given.

5. Equipment available presently in the antarctic is adequate only for field usage. Standard dental equipment with modifications should be substituted. The facility should be expanded to include prosthetics.

6. In future expeditions, it is highly recommended that a portable dental clinic be used.

7. Dental research opportunities are available in the antarctic.

MEDICAL AND DENTAL EQUIPMENT AND SUPPLIES

McMurdo

Medical

An electrically heated autoclave rather than the gasoline field model would have avoided the inconvenience of operation and the fire hazard of the latter. A more powerful X-ray unit was desired because of the complete unavailability of supplementary X-ray facilities for long periods. A refrigerator for storage of perishable products would have been well used.

In general, supplies reached McMurdo in good shape and were off-loaded satisfactorily. The packing of medical supplies in black boxes enabled them to be quickly spotted in the supply depot. They were unpacked as soon as possible to prevent damage from freezing. Certain items, such as rubber goods, were in some instances badly damaged or ruined by freezing.

Supplies were unpacked at McMurdo and stored wherever space allowed in the sick bay. Extra supplies and bulky items, which do not perish by freezing, were stored in a Jamesway hut, a few feet to the rear of sick bay. Alcoholic supplies

were stored in four security lockers to the rear of sick bay and narcotics were kept in a three-way combination safe.

Since no ships or aircraft can get into McMurdo from March to October, a 20-percent safety margin should be allowed on items such as narcotics, antibiotics, emergency dressings, and other special drugs. Large amounts of such items as 1000-cc bottles of sterile water for injection were recommended, since these solutions were heavily used for wound irrigation because of the poor water supply. Intravenous set usage falls into the same category. Improvization should not be relied upon too heavily when outfitting a remote base like McMurdo. Every effort should be made to obtain basic items, for with a small compliment of nursing help and because of the element of time, the medical staff may be sorely taxed to improvize.

Some major pieces of equipment that should be at McMurdo include a better water distiller and an orthopedic hospital bed with necessary attachments. The distiller was in poor condition and capable of distilling only a few gallons of water per day. A distiller capable of producing 5 gallons of water per hour is recommended. The high fracture rate at McMurdo was the reason the orthopedic bed was recommended. Also, since McMurdo is the evacuation center, it has the greatest number of patients, and at least one such hospital bed should be present.

McMurdo had a well-equipped pharmacy. Accurate prescription files were kept separately of narcotics, barbiturates, and general drugs. Inventories were made of existing narcotics, barbiturates, and alcohols. Expiration dates should be carefully checked on specific items like penicillin. Numerous penicillin injection vials and tablets had to be discarded, as did all DPT vaccine, the latter because of freezing.

McMurdo is in good shape with regard to supplies ordered and present. McMurdo has been, can, and should be used as the basic antarctic medical-supply center and storehouse insofar as possible. Additional warm storage space the size of a Jamesway tent should be provided. Probably the most inobvious but most inconvenient shortage of supplies at McMurdo was not medical, but housekeeping items, such as swabs, brooms, towels, and paper cups.

Little America

Medical equipment and supplies were ordered on the basis of logistic support or means of evacuation of patients. No single item was completely depleted during Operation Deep Freeze I. The amount of material remaining at Little America after Deep Freeze I was sufficient to maintain full medical operations during Deep Freeze II without resupply. Supplies and equipment proved adequate in all respects. Resupply items further augmented the medical stocks.

There are certain supplies and equipment which might improve the medical facility and should be considered for future operations. They are:

1. Medical X-ray apparatus, FSN 7525-612-5710, was the type ordered for the main bases. This is a simple unit to operate and reasonably compact. In many instances, however, the 15MA tube, which is standard on this apparatus, did now allow satisfactory films to be taken of thicker parts of the body. Spine films were of poor quality and abdominal flat plates were almost impossible. Good quality roentgenograms covering a full diagnostic range are essential.

2. A fuel-operated autoclave, sterilizer surgical dressing, FSN 6530-708-4490, was used. This is a very workable unit, with more than sufficient capacity. The fact that it is fuel-operated, however, makes it a fire and fume hazard. Electric power availability at Little America would allow substitution of an electric autoclave of the same capacity.

3. The operating room at Little America was provided with two lights, surgical, ceiling, FSN 6530-706-6525. These are excellent lamps, but the low overhead of the sick bay makes them an obstacle to personnel, who have difficulty in preventing their heads from hitting the lamps.

4. Laboratory facilities at Little America were extremely limited. There was a space limitation, and no running water was available. However, the range of diagnostic tests could be extended, despite these limitations, by simple additions of laboratory supplies. A detailed list of recommended laboratory items was submitted by message during the winter of 1956.

5. The medical library at an isolated base should be more extensive than under normal circumstances. The standard textbook kits do not meet the requirements.

6. The great number of dermatologic disorders, which were observed, was not anticipated. The treatment of these disorders would have been facilitated if there had been a wider selection of basic materials which are used in compounding dermatologic remedies.

No special packaging is required for most medical supplies and equipment going to the antarctic. No package will effectively safeguard freezable items if they are left outdoors in below-freezing temperatures for long periods after being unloaded. The best assurance against freezing and loss of material is rapid identification and transportation to heated storage. This rapid movement of medical supplies can be accomplished by the medical department personnel if the size of the crates is no greater than 7 cubic feet. This size allows lifting and hauling by manpower, and

would allow medical personnel to recover supplies without being dependent upon the availability of materials-handling equipment.

In most instances, field kits should be ignored when ordering supplies and equipment for a medical facility such as exists at Little America. Ordering of many different kits results in duplication of items as well as the inclusion of many unnecessary items. The following kits duplicate each other as well as duplicate many items which are ordinarily included on the initial outfitting list.

1. Medical Instruments and Supply Set, Dispensary Field, FSN 6545-919-1500.

2. Surgical Instrument and Supply Set, Detachment and Armed Guard, FSN 6545-919-7225.

3. Surgical Instrument and Supply Set, Combat, FSN 6545-827-4200.

First-aid kits for use in vehicles, aircraft, and other units operating independently from the main base were:

1. First-aid Kit, Airplane, FSN 6545-919-6650.

2. First-aid Kit, Motor Vehicle, FSN 6545-922-1200.

3. First-aid Kit, Life Raft, FSN 6545-921-7100.

These kits duplicated each other, and contain nothing more than compresses, antiseptic, petrolatum, water purification tablets, etc. None of the kits were considered adequate for a party operating at a great distance from Little America for six to eight weeks without a medical department representative. Kits had to be assembled in most instances from supplies on hand.

Medical Gas Casualty Sets No. 1 and 2, FSN 6545-924-8125 and 6545-924-9675, were definitely unneeded and only added to the burden of transportation and storage. The main component of the Anesthesia Set General, FSN 6545-299-8250, is Gas Apparatus, FSN 6515-301-0430. The remaining items in the set, which represent considerable expenditure, are mainly items which appear elsewhere in the initial outfitting list. An endotracheal anesthesia set was not included with this kit, and was ordered separately.

X-ray Equipment Set, FSN 6545-952-1550 was excellent. It contained all items needed for the taking and processing of X-rays, and in sufficient amounts. The only item which might be added to this kit would be replacement intensifying screens for the X-ray cassettes.

Recommendations. 1. That main bases be provided with either 30-ma or 100-ma tubes on X-ray apparatus. Units are available for converting the present units to 30-ma or 100-ma operation. The practicability of this should be investigated.

2. That the medical library should be supplemented according to the desires of the wintering-over medical officer.

3. That a different lighting arrangement in the operating room would be of benefit and should be investigated.

4. That possibility of substituting an electric autoclave should receive strong consideration.

Byrd

Upon arrival at Little America, the medical officer found all medical supplies at that base, with little hope of shipment to Byrd Station. However, arrangements were made with the aircraft commander to airlift 4000 pounds of essential items. The remainder was delivered by plane to the tractor train and thence to Byrd.

Almost all supplies were frozen, but of the small portion used no alteration was noted. The cold critical items were hand-carried to protect them from freezing.

Breakage was extremely low and was primarily due to differential contraction from the cold. All bottles of Amphogel and one of Benzalkonium were damaged in this way, but some of the contents were salvageable by thawing and filtering out the frozen solid contents.

A small selection of medical supplies, thought to be of value in a camp catastrophe, was placed in a steel box for inclusion in the emergency cache. All such material, because of the remote position of such a cache, was necessarily subjected to extreme cold. Accordingly, the value of such a procedure is unknown.

Of the items supplied, amounts were more than adequate and, based on usage rates, stocks will remain for many years.

South Pole

The medical supplies were very well packed. Of the large number of glass articles, only a few arrived broken, and it was evident that in these items the breakage was always due to freezing of fluid within the bottles. There was also minor breakage in such items as the analytical balance and the surgical calling lights. On the whole, however, considering the circumstances, the packaging was excellent.

Some effort should be made to prepare a standard outfitting list for small stations from the experience gained at these bases. If the drugs could be prepared in lots of standard amounts in bottles of the same size, it would represent a great saving in space; if all drugs were packed in square, wide-mouthed bottles of three different sizes, the packing would be greatly reduced. At the same time, neat stowage would be facilitated at the station, this being important where outdoor stowage at temperatures of -50 F to -60 F is necessary.

On the whole, the medical supplies were excellent in all respects. The fact that the vast majority of items were not used does not imply that they are unnecessary or obsolete; perhaps in the years to come they will be used.

In the category of drugs, it is worth mentioning that the large usage of antihistamines was due to the coincidence to two individuals requiring long-term daily doses, and is not to be taken as representative of a normal yearly usage. The usage of sleeping medication represents primarily a late winter usage; during the summer periods it is rarely necessary. None of the narcotics in the Deep Freeze II supplies was used. Codeine, the only narcotic used, was taken from the small supply sent with the construction crew in January 1957.

In the category of bandages, the Band-Aid is of the most practical importance because of the large number of small hand injuries seen and the apparent delay in their healing. It is often necessary to keep a minor cut covered for a week or ten days, where ordinarily a day or two would suffice.

The medical equipment deserves mention in two categories, heat and light. The most useful item for heating was the electric burner. This was found to be far more satisfactory than the Coleman stove. Although the latter produced more heat more rapidly, it was troublesome and required the use of gasoline in sick bay, which was considered dangerous when ether was being used in the laboratory. The effectiveness of the electric burner was increased by placing a layer of glass wool around the autoclave (pressure cooker), enabling generation to take place far more quickly.

Lighting was somewhat of a problem in sick bay. The surgical ceiling lights would not fit in the small space and were therefore set aside for emergency use only. For this purpose, they were converted into floor lamps by inverting them over their bases. Lighting in sick bay was obtained by using a photographic flood lamp. It had a firm tripod base, telescoping stem, and a large reflector head, all of which made it ideal for daily use and for minor surgical procedures. It is to be highly recommended for sick-bay use. A 100-watt bulb is more than adequate for use in this lamp.

Finally, it is recommended that some provision be made for sick-bay water supplies in the initial planning of a new base. Running water is perhaps unnecessary in the small base, but a large cannister or tank should be provided. The system in the South Pole sick bay was a simple 3-gallon thermos jug which was periodically filled with a bucket of water drawn from the head. This system was entirely satisfactory for everyday use, but would probably prove inadequate in event of an emergency. A rectangular tank which would fit snugly in the supporting beams of the building roof might prove the most satisfactory in convenience and space economy.

Two items which would be appreciated are a refrigerator for the biologicals and a strongbox for small supplies of sick-bay narcotics. Both these items should be small and as simple as possible.

Hallett

Medical equipment and supplies were adequate. Perishables such as glucose and saline in water, dextran, vaccines, and typing sera were taken care of immediately to prevent freezing. Liquor and narcotics were left untouched in a safety locker. Very few of these items were used at all. Vitamins were expended to some extent, but enough were left for the incoming group. One bottle (100 cc) of xylocaine was used. Band-Aids and gauze bandages were used very often. Emergency drugs were not used at all.

Wilkes

Medical-supply packaging was adequate in every case except one. The torsion balance was placed in a thin cardboard box without bracing or other protection to the metal bands which form the heart of the balance system. One of these broke in transit and makeshift repair left this band with diminished tension. The balance did seem perfectly accurate, however.

There was little difficulty with losing medical crates or freezing of contents at Wilkes. The black boxes were easily recognized when they were unloaded, and temperatures seldom fell much below freezing at that season. The freezing of Deep Freeze II biologicals was due, not to inclement weather, but to accidental storage of freezables in the deepfreeze rather than in the refrigerator.

The medical supplies were entirely adequate as to quality and quantity. The only items which were near exhaustion at the end of the year were Band-Aids and 4 x 4 gauze pads. These could easily have been constructed from the bulk or rolled gauze and tape still in good supply.

One category of equipment much missed at the beginning of the year was that of furniture, especially dust-tight cabinets for protection of sterilized packs. Workable shelves and a Mayo table were improvised of wood. The field operating table was excellent and easily convertible from examining to operating use.

Unexpectedly valuable items were the roll of wax paper and the chemical heating pads. The former was used in many applications about the base where protection of package contents from drying was desired. The latter were much preferred to hotwater bottles for application of local heat, because of their ease of operation and because they could be placed on an inflamed part at bedtime and maintain heat until morning. For continuous hot wet-soaks, the small electric vaporizer unit of approximately one-pint capacity was ideal. This could be turned on as needed, it heated water quickly, and the spout was ideal for pouring onto bandages.

Ellsworth

The selection and amounts of medical and surgical supplies furnished was very adequate. Although only about 5 to 10 percent of the medical supplies were used, it is considered necessary on an operation of this type to have enough medical and surgical supplies for any eventuality. Since resupply is impossible for six or more months, many drugs that are not ordinarily used still should be stocked.

The quality of the medicines and equipment was good. One notable exception was the portable operating table, which was not only worn but inoperable when received. The pressure-cooker type sterilizer served its purpose but was considered too small and antiquated for sterilizing. Another inadequate piece of equipment was the small water distiller. Its output was inadequate and the purity of water that could be obtained from it was below medical standards.

Three pieces of equipment not on the original list of supplies but considered very useful were a small portable dental motor with hand piece and a portable X-ray machine. The dental rig is often indispensable in opening abscessed teeth and is much safer in the hands of an inexperienced practitioner than an attempted extraction. A portable X-ray machine obtained from the icebreaker that accompanied us to the antarctic got plenty of use. A small diathermy unit would be useful to treat the numerous musculoskeletal injuries.

The volume of the crates containing medical equipment was very great. There was very little loss due to breakage. Although the crates were painted black and the drugs were packed in insulating materials, there was freezing of many items. Intravenous fluids, even though they had frozen, did not break the bottles or seals and were usable. An almost total loss from freezing occurred in the bottles of formaldehyde and liquid soap.

A more compact method of packaging should be used. Painting the crates black did help to locate medical goods during the off-loading. Crates should have an inventory of the items they contain in a pocket on their outside. It is important that freezable items be packaged in small, easily handled crates and that they be kept in a heated place if possible.

Dental

Three standard Navy field sets were the principal dental items requisitioned. These were (1) Dental Equipment Set, Operating, Field: Federal Stock No. 6545-918-005; (2) Dental Supply Set, Emergency Denture Repair: Federal Stock No. 6545-918-2750 and No.6545-927-4840. Also procured were miscellaneous instruments and supplies, sufficient for a year's unresupplied practice.

The dental chair, lamp, and motor proved to be thoroughly excellent pieces of field gear. A small but often troublesome feature of the dental chair was the lever which adjusts the headrest. By about midwinter this lever had been bent so many times that it yielded nearly every time it was handled thereafter. Towards the end it was necessary to use pliers or a similar tool to adjust the headrest.

The Field Dental Operating Equipment Set does not include a wrist-and-slip-joint (Federal Stock No. 6520-570-5150) which is required to accommodate the more common Navy angle and straight handpieces. The set is supplied with the less common hexagonal-sleeve handpieces. Good use was made of the small Field Emergency Dental Treatment Instrument and Supply Set. The hospital corpsman with the South Pole construction party employed it in treating a casualty. Until it broke in July 1956, the field medical X-ray machine produced excellent dental radiographs. The gasoline-operated field medical autoclave provided the dental officer with sterile sponges and sterile towels.

A small number of representative artificial teeth were not included in the Emergency Denture Repair Set. In the case of two of the prosthetic appliances repaired, each required the insertion of a new artificial tooth. Fortunately, a few such teeth had been procured from a supporting ship before it sailed away in March 1956. Some dental supplies are subject to damage by freezing. In the early part of the construction of the McMurdo Sound camp, the dental officer and the medical officer made sure that such items were kept in heated spaces, and consequently no damage resulted. The South Pole hospital corpsman reported that when it came time to break out his dental kit he discovered that the contents of all but four of the procaine-hydrochloride cartridges had frozen solid and had forced the rubber end-plugs out of the cartridges. Fortunately, the four located at the center of the can were still usable and he was able to carry out his treatment.

Space available at McMurdo Sound for dental use was 8 feet by 8 feet by 14 feet. Space available at Little America was 8 feet by 8 feet by 16 feet. Minimum adequate space for a dental facility in the antarctic should be 8 feet by 8 feet by 16 feet.

The basic equipment available for Deep Freeze II was adequate for field use only. Considerable improvisation was necessary to provide the care necessary for the men. The field chair was found to be inadequate. A standard pump chair should be substituted. A small roll-away working cabinet should be included since a bracket table is not available. It is felt that this table would be preferable to a bracket table when a corpsman is not available. Aspiration facilities were inadequate. A portable EENT cabinet with built-in aspirator is recommended. All water was hand-carried; tanks were available but limitations in space prohibited their use. Due to lighting inadequacies, it is strongly recommended that a light-colored paint be used in the dental office. Large paper napkins should be used as dental towels to compensate for laundry inadequacies. Equipment in an antarctic facility should include materials for crown and bridge repair and the facility should be capable of complete prosthesis.

Expendable equipment and supplies were all functional. Supplies were received in good condition. Packing was adequate, but a master list of dental supplies was not available. Dental supplies should be packed separately from medical supplies.

Recommendations

1. That the lever for adjusting the headrest on the field dental chair be made of heavier metal.

2. That a wrist-and-slip joint be included in the Field Dental Operating Equipment Set.

3. That a few representative artificial teeth be included in the Emergency Denture Repair Set.

4. That precautionary measures be taken to protect dental supplies subject to damage by freezing.

Section V

SPACE UTILIZATION

PERSONNEL AND ADMINISTRATIVE BUILDINGS

McMurdo

Camp Personnel

The population of the camp was made up of personnel from Mobile Construction Battalion (Special), Air Development Squadron Six, Task Force Forty-three and the U. S. Hydrographic Office. In addition, there were press correspondents, observers from the U. S. Army, and civilian scientists. From 20 December 1955 to 12 January 1956, the average population was approximately 35 personnel. From 12 January to 1 February 1956 the population increased daily to a total of approximately 150 and remained at this figure until completion of cargo off-loading on 14 February 1956. Following this, the camp population decreased gradually to 93 on 1 March 1956.

With the return of the aircraft, at the beginning of Deep Freeze II, the camp population increased disproportionately to the increase in facilities. By 31 October 1956, the population was 180; and by 15 November 260. During the period 15 November - 15 December, when air operations were at a peak, the population reached a high of 360. With the departure of the planes, camp habitation decreased somewhat but ship off-loading held the population at 280 through 15 January 1957.

Pioneer Camp

At the outset, personnel lived in ten-man tents pitched upon the snow at Hut Point. Sleeping bags and air mattresses were issued and, in general, the men slept upon the snow. The tents were unheated and unlighted. (Temperatures in the tents were close to the ambient; usually between 20 F and 35 F.) As supplies arrived in camp, improvements in quarters were possible, including the improvisation of decks and sleeping racks and the installation of stoves. The tents provided excellent wind protection, if properly secured, and sleeping

was comfortable. By 21 January 1956, personnel moved into permanent buildings as space became available, sleeping at first upon the decks and gradually moving into beds as these arrived in camp. Buildings were heated as soon as the basic shell was erected.

As the camp population increased, crowding in tents became severe for a period of approximately two weeks since tents did not become available in proportion to population increase. Six or eight men were assigned to each tent whereas five men with their gear were as many as could be comfortably accommodated. A similar disproportion between population and the number of sleeping bags necessitated using some bags in shifts, an unsanitary but, under the circumstances, unavoidable arrangement. Two 16-foot by 32-foot tents for use for messing, communications, etc. were provided.

Permanent Camp

Winter living quarters consisted of five panel-type huts 20 feet by 48 feet in dimension and 8 feet high. Each hut was divided into six compartments by incomplete plywood partitions. One compartment served as a lounge and was equipped with a table for reading material and games. Several chairs were placed about the lounge. The remaining spaces each had two double-deck bunks and four large upright lockers for clothes and personal gear. The floor was covered with linoleum, an important aid in the cleanliness of quarters. Heat was provided by two diesel-fuel-burning space heaters. Over each heater was mounted a large fan to circulate the heated air. These fans were continuously used and successfully prevented stratification of air in the buildings and marked vertical temperature gradients. The buildings were ventilated by exhaust fans placed at either end. Except in coldest weather, one stove was sufficient for heating each living hut. Due to the low outside temperature, the humidity of the air in the huts was extremely low. Open pans of water placed on the stoves made only slight improvement. At first there were some complaints of dryness of the respiratory passage and a few nose bleeds, but personnel appeared soon to become accustomed to the dryness and no detriment to health was caused by the dryness. In each hut automatic fire and carbon monoxide alarms were installed.

Personnel found the huts completely comfortable with regard to protection from the wind and cold. With twenty men in each building, however, the living spaces were crowded and this condition was accentuated by the large quantity of bulky clothing required in the cold climate. During the period of isolation, the incidence of respiratory disease was very low, and the crowded sleeping spaces did not present a problem in the spread of disease. However, during the summer period, crowding constituted a distinct health hazard.

Toilet and washing facilities were provided during the winter in two separate buildings. Inhabitants of the barracks most remote from a head were required to traverse, in the open, approximately 75 feet along the camp street to reach the toilet. But even in the worst weather this was no particular hardship. Each head was provided with a stainless steel trough urinal, the drain from which carried urine to a replaceable receptacle beneath the building where it quickly froze. Each head had three seats for defecation, each placed over a receptacle which could be disposed of and replaced from outside the building. A washstand was built over a disposal tank and three pairs of hot and cold water taps with washbasins were provided for washing and shaving. Wastes from the wash water-stand tank were drained to the outside. Hot water was kept available in an oil burning heater tank in each head. Water for the heads was pumped into an overhead tank in the building from the snow melter located at the rear of the galley, about forty feet from the farther head. The heads were not well designed. They were too high with too much wind surface and were forever moving.

Shower and laundry facilities were located in the power house building. These consisted of shower stalls to which hot and cold water was pumped under pressure. Washing machines and clothes driers of the domestic type were provided and were adequate for the laundry needs of the wintering party. No dry cleaning or pressing facilities were available. Water for showers and laundry came from a snow melter located in the power building. Wastes were discharged from showers and washing machines directly onto the adjacent hillside.

One building centrally located in the camp was used for messing. Its dimensions were 20 feet by 96 feet. Approximately half the area was used as a mess hall, with a seating capacity of 72. The remainder was used as galley and pantry. The construction and equipment of the galley was such as to make completely satisfactory sanitary conditions impossible. Food preparation tables were improvised from material on the base and the surfaces were rough and porous and could not be adequately scoured. Dishwashing was by hand in open sinks. Mess cooks could not handle the dishes in adequately hot water, so wash water and rinse water temperatures were less than recommended. No disinfectant was available for inclusion in dishwater. Plastic eating utensils were provided, and the supply was so short that cracked pieces could not be retired from use. Benches and serving counter were built locally and covered as well as possible under the circumstances, but were such that cleaning was unsatisfactory. The galley floor covering was similarly makeshift and unsatisfactory. Drains from galley sinks emptied into an open tank at the rear of the galley, from which wastes were pumped outside to a waste water sled for disposal. This open tank was unsightly and occasionally odorous. With care it was kept sanitary.

Food was stored either in an unheated Quonset hut or in the open and was brought in small quantities into the galley for thawing before use. The necessity of using the relatively limited galley space for this purpose aggravated crowding in the galley and detracted from the cleanliness. Frozen meat, vegetables, and fruits were stored in walk-in refrigerators. In the winter months, the cooling mechanisms of these refrigerators were not used, but during the summer months, cooling was necessary to maintain proper temperature. Only one chill box (temperatures 38 F) was available in the galley. This did not provide adequate space, particularly in summer when milk, eggs, and fresh produce were occasionally available from New Zealand. During the isolated winter period, the messing facilities, though marginal, were satisfactory. In the summer, however, they constituted a substantial health hazard because of the greatly increased number of personnel in camp.

A scheduled plan for improving buildings was a continuous winter program during Deep Freeze II. The interior walls and ceilings of the galley and mess hall were aluminum foil and scrubbing them monthly brightened up the whole building. (Painting of the aluminum is not recommended).

A connecting building was constructed between the galley and the storeroom, to house a 750-gallon capacity bitumen heating kettle and two additional 1000 gallon tanks. The remaining part of the structure was used for storage of canned provisions for the galley. The 20 foot by 48 foot storage area was adequate to support 87 men for a period of nine months.

A Quonset-type building was selected for the Task Force Commander's Headquarters. It was favorably located to the airfield, communications and chapel. A double bedroom with wash facilities was installed and a 10-foot by 20-foot conference room. Three additional double-bunk rooms were partitioned off. The entire building was lined with plywood and painted. The roof leaked for a short period during the melting season but soon stopped. This type building can easily be adapted to meet all the requirements for summer living and for a presentable headquarters.

Sick Bay Facilities

On 22 December 1955 a ten-man tent at the Hut Point Camp site was assigned to the medical department for use as a Sick Bay. Pitched on snow, the tent had no deck. The snow melted out beneath the stove making its use hazardous. A diesel-fuel-burning Yukon stove was provided for heat. With the stove on, the average temperature within the tent was about 35 F which is too low for the care of either ambulatory or bed patients. Without windows, the tent was inadequately illuminated by a gasoline lantern. Folding wood and canvas cots with sleeping bags were provided for bed patients. The care of patients is greatly impeded by these primitive accommodations.

On 25 December 1955 one-half of a tent (FWWMR, General Purpose, Medium) was assigned for use as a Sick Bay. This gave a 16-foot by 16-foot enclosed space with 5-foot side walls and a peaked overhead which was adequate for the requirements of the camp at this stage. Though pitched on snow, the tent was provided with a plywood deck.

Plastic window panels admitted adequate light for working. Thus arranged, the Sick Bay was adequate for a shore party of 90 men with close support from ships. These Sick Bay facilities were utilized until the winter quarters were ready for occupancy.

The Administrative Offices were located in a Clements-type 20-foot by 56-foot building, jointly occupied by the Medical Office, Dental Office, Officer of the Day's Office and the Officer in Charge; the Administrative, Officer in Charge, and OOD offices being in the front part of the building, with the Dental and Medical offices in the rear. Much confusion existed, since the OOD's office was the nerve center of camp and all camp functions and operations passed through him, and personnel desiring to see the Medical, the OOD or the Officer in Charge, all passed through the Administrative Office. This undesirable condition existed until 12 July 1957, at which time additional space was required by the Medical Officer to accommodate the victims of a helicopter crash. The Administrative, Officer in Charge and OOD officers were then moved into the Library building, a 20-foot by 48-foot Clements-type building, which also contained the Public Works Office, Chaplain's Office and Dental Office.

The Sick Bay area provided was approximately 44 feet by 20 feet, of which the dental office occupied 68 square feet. The medical officer's quarters and office were in the Sick Bay area. The remainder of the space was divided into an operating room with 96 square feet, a general Sick Bay area of 144 square feet, one room for a patient of 36 square feet, another patient's room of 42 square feet, a drug room of 48 square feet and a utility room of 278 square feet, part of which could be used for patients, if necessary. One of the rooms was constructed for secure detention of disturbed psychiatric patients. For other patients, three permanent beds were provided and three additional beds could be set up if needed. Space for an X-ray developing darkroom was provided during the winter in a building adjacent to the Sick Bay. In the summer when this space was needed for other purposes, X-ray film processing was carried out in the photographic laboratory. A field autoclave, 15 milliampere X-ray machine, and a wide variety of drugs made the dispensary very well equipped.

Summary

The problem of housing at NAF McMurdo was one of overloading and overcrowding facilities from the standpoint of utilization. The facilities were designed for a maximum of 180 men. During the summer of 1956-57, as many as 350 men were berthed in the camp. A total of 18 Deep Freeze buildings and 15 Quonset huts, plus several temporary shelters, partial buildings and building additions, were erected by Deep Freeze I forces. Deep Freeze II brought Deep Freeze type recreation and communications buildings and one Army T-5 type building to make a total of thirty-six permanent type buildings. Deep Freeze II also brought several Jamesways and Atwell shelters for use of summer personnel. This provided sufficient berthing space, but the overload on messing, sanitary facilities, water and laundry facilities was almost prohibitive. Almost any enclosure is satisfactory for housing during the summer, provided it has a floor.

Most satisfactory and practical for housing the summer population were the Jamesway and Atwell huts. They are light and rapidly erected. They are snug and easily heated. When properly secured, they are safe in high winds. However, care must be taken in this. One hut was lost in a high wind in the process of erection before it was tied down. Two-man tents were used by the Cape Bernacchii survey party in March 1957 and as emergency equipment aboard aircraft. Jamesway tents are satisfactory for temporary housing of personnel in summer, and each one can quarter approximately twelve people if necessary, but six would be more desirable. A stove may be installed in each tent, giving satisfactory warmth. Ventilation depends upon the strength of the wind, but in normal conditions the ventilation is satisfactory unless it is overcrowded. Atwells are huts similar to the Jamesway, but superior in performance both from warmth and ventilatory standards.

Sleeping bags were certainly useful in the antarctic from two standpoints. They were used by summer personnel in lieu of bedding and were carried aboard all aircraft at the rate of one sleeping bag per man. Sleeping bags are preferred by personnel using a canvas cot for a bunk and by most transient personnel. An air mattress should be used in conjunction with sleeping bag for the mattress provides good insulation from the cold. In general, one should sleep in a sleeping bag with minimal clothes on, such as the issued underwear; outer garments should be removed and hung up to dry. A large reserve supply of sleeping bags should be maintained in the antarctic, as these items are easily torn and become very dirty during one summer season. All used bags should be returned to CONUS or New Zealand on the last ship for cleaning and repair, and flown to McMurdo the following year in quantities equal to incoming personnel. Of the new permanent buildings provided for McMurdo Sound, only one, the recreation building, was erected prior to departure of

MCB (Special) Det. One. It was easily erected, and, except for the foundation, was completed, including wiring and heating, in 200 manhours. Not all of the panels for the new communications building were received. Foundations for the communications building and for the barracks (Army T-5 building) were in place.

Conclusions

In general, the facilities provided were adequate but several improvements could be made. Running water was not available in Sick Bay and this would be most desirable. Storage space was limited. Items which might be damaged by freezing were crowded into the Sick Bay area and other items were stored outside exposed to the weather. More indoor storage space, both heated and unheated, was needed.

Dust was a big problem; the Sick Bay area was mopped as much as six times a day to keep it down.

After the helicopter crash there was very limited bed space and a shortage of certain supplies due to heavy unanticipated usage.

Another problem was the inadequate water distillation apparatus.

Recommendation

That additional summer housing be provided on the basis of estimated requirements. The Jamesway or Atwell huts are highly recommended.

Beardmore

All hands ate, worked and slept in one Atwell hut. One tent was used to house the generator and another tent was used for storage.

Little America

In general, the habitability of Little America V during the mid-winter months was excellent. The living spaces by necessity were crowded, with four men occupying each compartment in the barracks buildings. The compartments measured 16 feet by 8 feet and contained two double bunks and two large lockers. Each of the barracks had its own lounge space with table, lamps, and sofas.

The furnishings as a whole were quite satisfactory. The following discrepancies were noted: The steel folding chairs were not substantial enough and required much repair, mainly welding. The iron-framed lounge furniture was quite susceptible to breakage and needed constant attention. The lounge cushions were quite difficult to keep clean. As a substitute

for the steel folding chairs, aluminum folding chairs should be used - they are lighter and much more substantial. The iron framed furniture should have stronger welds - all breakage was at the weld. The furniture cushions should be covered with an easy-to-clean plastic.

The scheme of dividing the barracks into separate four-man living spaces and lounge was wasteful of space to some extent, but was greatly preferred by the men because of the small amount of privacy which was afforded by this arrangement. Separate thermostatically controlled heaters were installed in each barracks, as well as ventilating fans. A tunnel connected all buildings and protected personnel from the wind in going from building to building, making outdoor clothing unnecessary when leaving the barracks for the chow hall or latrine, etc.

There were two heads at Little America V, each located at opposite ends of the base and connected to the various buildings by the main tunnel. Each head had three toilets and one urinal; two showers were located in one head and one shower in the other. Washstands were also located in each of the heads. Running hot and cold water was available in the showers. No running hot and cold water was available at the washstands. No method was available for emptying waste water from the washbasins except by pouring it into the urinal or shower. The heads were adequately heated by blowers and space heaters. Lighting in the heads was poor especially over the washbasins, where it was inadequate for shaving. "During construction, the heads were changed to relocate the waste pit to the end of the building away from the sills. It was felt that the pressure of the foundation sills on the edge of the waste pit in the original location might cause it to cave in."[8]

Laundry machines and dryers were located in each of the heads. Each barracks had assigned days for laundry each week, and the laundry was done by a detail of men from each of the barracks. Laundry facilities were adequate during the wintering-over period. "During construction, changes in the mess hall layout were made to provide room for equipment. The two 60-gallon fuel tanks were placed outside and the fuel lines run under the building. The waste tank under the sink was not used. The space heaters were not installed."[8]

Living spaces, sanitary facilities, and messing facilities at Little America V were designed to provide adequate standards for a maximum of 73 men. During the spring and summer 1956-57, the base population increased to 240 without a corresponding increase in any of these facilities. The 240 officers and men at Little America V still had but 6 toilets, 3 showers, 4 washing machines, and 74 permanent bunks. Because of the overcrowding at Little America V during late December 1956 and January 1957, a policy of sharing cots was put into effect, until such time as additional Jamesway huts and barracks were erected. Overcrowding presented

a serious threat to health, occurring at a time when many new arrivals were coming in contact with isolated wintering-over personnel. This was also a time of increased fatigue on the part of all men due to the increased tempo of work. During this two month period there was a great incidence of illness. In addition, the severe crowding and a total lack of recreational space lowered the morale of the personnel.

Medical Building Requirements

Darkroom space provided was adequate. There was no running water in the Sick Bay, but it was found that satisfactory X-rays could be obtained by developing in the tanks in the medical darkroom, and then taking X-rays to the photographic darkroom for thorough rinsing. Laboratory and storage room was adequate for lab tests performed at Little America V and served as pharmacy. Metal shelves were installed in this same room for stowage of all medicines and a working stock of 6510 items. "During construction the interior of the Sick Bay was changed to eliminate the lounge and increase the size of the operating room."[8]

The operating room was also the main working space in the Sick Bay and was the space in which routine sick call was conducted. The operating room contained the X-ray equipment, autoclave, operating table, sink, and the medical officer's desk. It is poor practice to have the operating room exposed daily to the main stream of traffic, but this situation had to be tolerated due to lack of available space for a separate, small isolated operating room. The space designated as medical officer's quarters would provide an ideal operating room if quarters could be found for the medical officer in another building. The presence of the fuel operated autoclave in the operating room precludes the possibility of autoclaving instruments during an operation where volatile anaesthetics are being used.

The ward has sufficient space for two double bunks, which gives the Sick Bay four patient beds under ordinary circumstances. This amount of space was not available for in-patients after 1 November, however. Upon the arrival of the VX-6 dental officer in November, a portion of this room was made available to him as a dental operating room. This left the Sick Bay with only two beds available for patients. From November through January the availability of patient beds was critical at Little America V.

A large part of the Sick Bay building space was used for quarters. In view of the crowded circumstances within the operating room, the lack of space for a dental office, and the critical shortage of patient beds, it is felt that the housing of personnel in the Sick Bay building should be terminated. All space within the building should be used for

medical or dental working spaces. Particular mention is made of the undesirability of having the Captain's quarters and office associated with the Sick Bay. Not only did the presence of the commanding officer detract from the Sick Bay's atmosphere of accessibility to the men, but it also encouraged the practice of using the Sick Bay for berthing of VIP's during the summer 1956-57. During this period, officers were berthed in the space designated as commanding officer's office, as well as in corpsmen's quarters. At the same time there would have been absolutely no space available in Sick Bay, or any other part of the base to handle multiple injuries which might occur from aircraft or other serious accidents.

During the winter months a heated wanigan on a twenty-ton sled was brought up close to the rear exit of the Sick Bay and provided needed indoor storage area and autoclaving space. With this exception, the spaces were the same as the previous year. The gasoline field autoclave proved most adequate. Due to the fire and carbon-monoxide hazard, however, it was necessary to remove it from the immediate Sick Bay area. In September 1957, the wanigan was removed and no indoor autoclave space was available. For one month, autoclaving was done in the outdoor passageway and resulted in cracking of the outer shell of the autoclave where it had been previously welded. An electrical autoclave was provided for the relief detachment.

The danger of fire and explosion with the use of volatile anaesthetics presents a grave hazard in this isolated cold situation. A diesel-oil-burning "Jet Heater" was present in the Sick Bay and had to be secured during an ether anaesthetic. An emergency heating source is needed. The Herman Nelson provided was not thought adequate, due to the fume and spark danger prevalent with these units. A satisfactory solution was not found. An outdoor gasoline heater ducted to an indoor hot-water radiator would seem plausible. Steam-tight light bulb fittings were provided and are effective. Anti-explosive electrical outlets had been previously installed, but proper fittings were not available and these were ineffectual. The deck presented an additional hazard, as it was non-conductive. Two six volt automobile batteries provided source for an emergency operating light. The emergency lighting is necessary due to frequent power failure. An overhead castle light with two balanced type minor surgical lights provided adequate surgical illumination and were used sparingly to conserve the lamps.

Conclusions and Recommendations

Separate operating room should be established which is isolated from main sick call room.

Commanding officer's quarters should not be located in Sick Bay building, nor should Sick Bay building be used as temporary quarters for VIP's.

At least a four-bed ward is required.

Space is required for a dental office within the Sick Bay building.

Habitability for 73 men at Little America V was adequate during wintering-over period.

Compartmentation of barracks into separate four-man living spaces and lounge is desirable even though it does not offer the maximum utilization of space.

Method of disposing of waste water from washbasins is not satisfactory at Little America V.

Overcrowding at Little America V was a most serious threat to health and morale during spring and summer 1956-57 when population increased from 73 to 240.

Byrd

Sick Bay Installation

The space designed for Sick Bay in the building plans was small and used as the official sleeping place for the Officer in Charge. By removing a passage partition a larger alternate space 10 feet by 15 feet was created.

Miscellaneous items were stored in the overhead girders. In the event of a major surgical procedure, items could be quickly removed from Sick Bay giving a considerably larger "sterile field". The sink had hot and cold running water blended to issue in a fine spray permitting a surgical scrub and gowning in the room. The drainpipe for this sink occasionally became obstructed by ice if the draining valve were left open overnight allowing small amounts of water to run down and freeze before clearing the pipe. Narcotics and medicinal alcohol were stored in a locker in the OinC's room.

Berthing

Living space was inadequate due to failure of the barracks building to arrive. The two buildings in which ten and twelve men respectively slept were primarily designed for the operation of scientific equipment and programs. In one of these (Building #2, housing twelve men) 24-hour operation of Naval communications and meteorology caused considerable disturbance to the occupants attempting sleep.

South Pole

During DFI the men slept in the Jamesway #2 either on canvas folding cots with air mattresses or on beds from the shock cushions dropped with the equipment. A single sleeping bag was too warm unless the stoves were turned to their lowest positions.

Sleeping Bags

There was no occasion during Deep Freeze II to use sleeping bags. Warm buildings were available from the start, and there was no traverse work done. During the first two months, however, there was neither linen nor blankets, and so sleeping bags were used indoors.

During this period, the Arctic Sleeping Bag (M-1949) was found to be the most satisfactory. The bag could be placed underneath the sleeper while the opened cover could be used as a blanket. The two units were connected only by overlapping at the foot of the cot. The system permitted the sleeper to have ample warmth but to have easy access to ventilation if necessary.

Two of the men in the colder corners of the Jamesway barracks continued to use sleeping bags throughout the year in preference to linen and blankets. The bag mentioned held out remarkably well during the year with the exception of the fine lining material of the sleeping bag which showed considerable wear and tear in the lower portion around foot area by the end of the year.

The galley, mess hall, meteorological spaces and communication shack were located in one building with the Rawin dome located on a tower on the roof. Soot and grease from the galley were a constant problem in the meteorological and radio electronic equipment, a situation which was partially remedied by separating these from the galley with a solid bulkhead. However, as there had to be access between the two sections of the building, the solution was not a perfect one.

For optimum operation of the station on a permanent basis an additional building should be provided to house the galley, mess hall, and recreation area. This would allow meteorology and communications additional highly desirable space in the present building.

Barracks Building

This building housed twelve men in two-man rooms, with two additional small spaces at one end, used for fuel storage, clothing storage, and the emergency 4-KW Hercules generator. Space allocation is ample for the men, each room being about 8 feet by 16 feet.

The head contained the darkroom as well as head facilities; the head was somewhat crowded, though adequate for all basic needs.

Sick Bay

Sick Bay was in a far corner of the science building in which the heat was poorly circulated. Temperatures would often be in the low 50's in Sick Bay and in the 60's elsewhere.

In December 1957, a small 16-foot by 16-foot Jamesway was erected at the grid southwest corner of the base near the mess hall, to house the library, ships store, and recreation gear.

A Jamesway proved highly successful as a permanent barracks. It is divided into two sections. The first 32 feet is partitioned into six one-man rooms, the remainder, unpartitioned, serves as a lounge and storage area. A urinal in one corner, with a pit dug beneath the building proved a great boon.

Wilkes

The interior furnishings supplied for the buildings were satisfactory. The beds which featured innerspring mattresses were quite comfortable. The lounge furniture was good although slipcovers would have been of great value. A larger quantity also could have been used since sitting space was usually at a premium. The large supply of folding chairs was of considerable value. An additional galley table would have allowed all station personnel to be seated at once. The supply of lockers for personal use was inadequate and they were difficult to assemble.

Some rearrangements of the original Sick Bay plan of 300 square feet in a 48-foot by 20-foot Clements hut was necessary because of enlarging and pre-empting of the area designated originally for sick room as quarters for the officer-in-charge and chief scientist. This was considered necessary because of crowding resulting from twenty-seven men being assigned to quarters designed for twenty.

The space remaining was divided into four component areas: (1) A 7-1/2-foot by 6-foot laboratory with five shelves, two benches, and a stand for a water tank; (2) a 4-1/2-foot by 7-foot storeroom with three 3-foot by 6-foot by 10-inch metal, five- and six-shelf open cabinets, and one 4-foot by 5-foot by 18-inch wooden three-shelf cabinet; (3) a 15-1/2-foot by 9-1/2-foot Sick Bay proper, containing an 8-foot bench with two 8-foot shelves, a 4-foot by 6-foot by 18-inch six-shelf wooden cabinet, a field operating table, and an aluminum desk and (4) a 7-1/2-foot by 9-1/2-foot combined sick room and doctor's quarters. The major shelves were installed, and unpacking and stowing of crated supplies was complete by 23 February 1957.

SHOPS

McMurdo

Area

The shops area was considered insufficient during Deep Freeze I. The mechanics could work on a maximum of three small pieces of equipment (weasels) or two large pieces (D8 and D4) at any one time. Even then, work was accomplished under crowded conditions. The welders had no space allocated to them so they built a 20-foot by 20-foot extension onto the garage which served them well. The utility men had a small work bench in combination with the electricians in a 20-foot by 20-foot extension added to the powerhouse. The carpenters were allowed a small space in the garage. The aircraft shops are undersized for the amount of air operations conducted.

A Public Works shop building, of Clements panels, and measuring 20 feet by 56 feet and an adjacent garage building of Quonset frames and plywood, the same size but higher overhead, was constructed in May 1957 after the garage fire 28 April. The electric shop, located in one corner of the Public Works shop building, had an adequate area of 200 square feet. It had two large workbenches, and storage bins along one bulkhead. Sufficient tools for the needs of the electricians were available. The carpenter shop was of equal size and adjacent to the electric shop. It had adequate hand tools but the only power tool was a small 6-inch circular saw which is normally used as a hand tool. The carpenters constructed a table on which they mounted the circular saw. The shop had a long workbench, a closet for storage of small miscellaneous items, storage bins for nails and screws, and a storage rack for pieces of plywood and other miscellaneous lumber.

Equipment

The shop equipment for Deep Freeze I was considered insufficient. The carpenters' power equipment comprised one DeWalt 10-inch saw. The machinist had a lathe (South Bend 14-1/2 inches, a drill press and a rebuilt AEC metal band saw. The utility men used an Oscar Pipe Cutter and Threader.

The utility shop had an area approximately 10 feet by 36 feet in the Public Works shop building. It had a small workbench and a large number of storage bins along one side, which contained high usage items. Sufficient tools and spares were available for the repair of space heaters and the fabrication of simple plumbing and heating parts. The garage shop consisted of an area in the Public Works building equal to that of the utility shop, and it contained a good sized workbench and hand

tools and space sufficient to work on such items as carburetors, heaters and small engine parts. Most of the vehicle repair work was done in the garage building which contained nothing but a large open space for equipment. A lean-to storage room was constructed in June 1957 of plywood alongside the Public Works building, and was used primarily for spare parts required by the garage.

Garage spaces and shops can be considered adequate only because the job got done. Actually, about three times the amount of space available could have been effectively used. Because of the garage fire the tool situation was critical the rest of the year. Power tools such as a lathe and drill press were available only in the aviation shop building which was about a half-mile away.

Storage

Storage was very limited. Tool rooms were fabricated during Deep Freeze I by putting extensions to buildings and by storing parts on boards laid between roof trusses. A hull from a wrecked C-124 was connected for storage and shops but this was extremely cold for shops. The mechanics in particular require permanent storage space.

A welding shop was constructed in June on the end of the Public Works shop building. It contained arc and acetylene welding equipment material, as well as a 500-pound Ansul fire extinguisher with long hoses for the protection of the Public Works building and its adjacent lean-to.

Recommendations

A Butler building is definitely recommended as a shop for Deep Freeze III. Space along walls could be allotted to various construction ratings.

A thorough review of shop equipment is recommended, taking into consideration present facilities as well as plans for Deep Freeze III and IV which are unknown to Deep Freeze I personnel. The lack of effective shops during Deep Freeze I was a primary cause of unsatisfactory equipment operations during this period.

Little America

The builders and electricians shops were constructed beside the powerhouse and derived heat from a space heater and a duct from the powerhouse. This arrangement proved very satisfactory as the tunnel protected the shops and it was possible to use only plywood with no insulation for the construction.

The UT shop, which had been located in the same building as the carpenter and electrical shops, was moved to a new location in the addition to head #17. It was constructed of box material from the 30kw generators. In spite of the lack of insulation, the shop was satisfactory. Heat was obtained from the head. Total area in this new location is 128 square feet, and it provided adequate space for a workbench and storage of tools. However, little storage space for parts and supplies was available.

The other major change in the shop setup was in the garage where a 36-foot by 44-foot addition was erected. This enabled the mechanics to house simultaneously one D8, two M29-C weasels, two D-4's and one Sno-Cat. Not only did this facilitate maintenance of equipment, but it enabled transportation to keep an assortment of vehicles ready for immediate starting at the commencement of the workday during extreme cold weather. It was only the fact that equipment could be accommodated in the garage that enabled Deep Freeze II personnel to recondition all D8's for the October swing to Byrd Station.

The addition of a spare parts storage room of 24-foot by 40-foot dimensions made possible ready access to most of the supplies that would be needed for maintaining all equipment. There was, however, a dearth of stowage space for building, electrical, and utilities supplies. Adequate covered areas to stow all consumable gear and small equipment is a necessity.

The overall tool situation was quite good for all trades. One glaring deficit was component parts for the machine shop lathe. There were many times when a lathe was the only answer. Parts for all types of equipment and appliances were fabricated, from time to time, on the lathe, though usually the lathe tools were makeshift and certainly not satisfactory. Proper component parts were ordered in the resupply report. There were many examples of excesses in tools of all trades. This was due, no doubt, to the anticipation of a high breakage and loss rate. For example, the builders had a great assortment of saws; the utilities men had a great collection of pipe wrenches (many of which were too large for any conceivable use at Little America). It was noted that many mechanics' tools were not satisfactory. In almost every case the defect was noted to be in a general stores item. Therefore, it is suggested that such tools be of a higher grade, such as may be procured through open purchase.

All aircraft maintenance shops, except electronics, were in the aircraft maintenance building. The west side of the building was occupied with work benches and sheet metal storage racks. The shops were outfitted with a drill press, grinder, arbor press, a metal brake and oxy-acetylene welding equipment. One end of the workbench area was set aside for an

electrical shop. The north end of the building was taken up with the hydraulics and welding area and a small bunkroom. Along the east wall were an enclosed tool room, multiple storage bins, three units of Spar GCA, and an enclosed cage for stowage of survival and navigation gear.

Byrd

Shop space was limited to approximately 400 square feet in the powerhouse, with a 20-foot workbench running along one side. Maintenance of three IGY Sno-Cats caused excessive occupancy of this space for six months during the winter night period. The majority of the individual tool kits allocated to each rate failed to arrive and full use was made of an assortment left by the original construction group.

Most of the shop equipment finally reached the base by tractor train in October 1957. This included a lathe, power drill and a power saw. Several IGY disciplines brought their own tools and a small workbench was equipped in building 6. Since this area was also a berthing space, operation hours were limited.

South Pole

The garage ramp was eliminated as it could not be shipped and would be impractical to use even if it could have been built. In its place a 20-foot tunnel extension was built covering the garage doors and protecting them from drift. The garage doors were relocated to the leeward side of camp. They were redesigned and erected to provide an accordion type arrangement. As originally designed, it would be impossible to use the first ten feet of garage space.

The garage powerhouse contained the two 30kw generators, snow melter and water storage tank, and shop spaces. Both the weasel and D2 could be garaged at the same time, however, this used all available deck space and made shop work nearly impossible.

An additional building should be provided for all shop work except mechanics work, and to provide additional covered storage for vehicles. Sawdust and other debris from carpentry and electrical work were a major nuisance, clogging generator engine radiators and getting into the generators themselves.

Shop spaces for the builder, mechanic and utilitiesman were in the garage, and for the electrician in the enclosed space between garage and head. Space allocations were physically adequate, except for welding, which had to be done too close to the generators and inside fuel storage.

Hand tools were in adequate supply; specialized tools and equipment were not. Items ordered for Deep Freeze III, if procured and delivered, should largely correct deficiencies which existed during Deep Freeze II.

Hallett

Garage Shed

A lean-to type structure, 32 feet long, 12 feet wide and 8 feet high, was added to the north side of the garage to provide a readily available storage space for parts and equipment. It was constructed utilizing 2-inch by 4-inch framework covered with 1/4-inch plywood. A small access door was cut through the garage into the lean-to, and an 8-foot by 6-foot door was cut into the east side of the lean-to.

A further modification was made to the garage building by removing the hinges of the main doors from the overhead and rehinging these doors on the sides. This allowed an easier method of opening the doors and added 4-inch overhead clearance.

The floor panels of the garage were inadequate to support the load of a model 955 traxcavator equipped with standard tracks due to the fact that on a hard surface the cleats of the track shoes were carrying the entire weight of the tractor. The three center floor panels in front of the door were removed and 8-foot sections of 2-inch by 6-inch timbers were laid in place of them. This provided support for the tractor and increased the overhead clearance. The shops were believed adequate. The mechanics and electrician's shops were located in the garage which was also used at times as a carpenter shop. The utilities shop was located in a Jamesway hut. The electronic repair shop utilized a portion of the radio room.

The standard tools provided were considered adequate for the jobs required. Some special tools were not received which caused delays in some repairs, but in all cases the repairs were completed.

Utility Buildings

After the completion of formal construction the decision was made to construct an extra building to house the evaporators, snow melter and water storage tank. With the completion of the foundation the construction detail was evacuated and the construction of this building was left to the wintering-over group. Utilizing spare Clements panels and roof trusses, a four-man crew completed this project in 60 hours. The roof of this building was then covered with canvas and battened down. Heat was furnished by a Preway space heater, and electric lines were run from the auxiliary power building (building #11). This building, when completed, was designated as the utilities building.

After the development of the generator exhaust snow melter system, the UT building was modified by constructing an 8-foot by 6-foot darkroom in the area which previously housed the snow melter. This darkroom was constructed with 2-inch by 4-inch framing covered by 1/4-inch plywood. A sink and electrical fixtures were installed in the darkroom, and it was painted black and made light proof by sealing with black cloth.

During October it was decided to remove the evaporators and convert the rest of the building into a recreation room. The removal of these evaporators was accomplished by removing two standard side panels and dragging the evaporators out through this opening with a D4 traxcavator. After replacing the panels, the building was cleaned and painted. Linoleum was laid and the recreation equipment was installed. When a Chaplain was available at this station the building was also used as a chapel.

Wilkes

A Clements hut erected from a miscellaneous assortment of panels comprised the carpenter and plumbing shops. There was adequate space for both. Tools for both shops were generally adequate for the work at hand. However, the loss of the carpenter shop's radial saw was a hard blow to the builder. The motor for this saw was received with an internal short. Therefore, all work was accomplished either by hand saws or Skilsaws.

A section of the powerhouse was set aside for the electrical workshop. There was adequate space and tools to accomplish necessary work.

A portion of the Aerology/Electronics storage Jamesway hut was set aside for an electronics workshop. Test equipment was adequate but the addition of a vacuum tube DC voltmeter would be of value. There was a bad shortage of small screwdrivers and tuning tools; otherwise tools were adequate.

A portion of the garage was set aside as a workshop. Space was not quite adequate though necessary tools and equipment were.

Ellsworth

Service Station

A central service station and repair area was set up at the temporary camp. A Herman Nelson heater was borrowed from Air Development Squadron Six for use by the mechanics. Such a unit should be included with construction equipment for use of the mechanics for equipment repair in the early stages of such an operation as this.

Tools

A large quantity of MCB ONE hand tools were taken with the unit. It was intended to return these to Davisville for future use of the battalion. After the alert for evacuation was given, the WYANDOT got underway with the STATEN ISLAND remaining to evacuate the construction personnel for a later transfer at sea to the WYANDOT. Because of the rapidity of evacuation required use of hand tools to the end, and work remaining to be done after evacuation, it was impossible to get the entire lot of hand tools out. Certain high-cost items, such as survey equipment, Skilsaw, and electric drills were "hand carried" out. Remainder of tools were left with the wintering-over personnel for their use.

AVIATION AND COMMUNICATION BUILDINGS

McMurdo

Realizing that something more than a roving weasel would be required for a control tower, spare Deep Freeze panels were prefabricated at Davisville into an eight foot cube with plastic windows inserted for vision. When assembled, it was easily mounted on a 20-ton bobsled. Radio units were prefabricated for ready installation within the tower upon reaching the ice.

At the beginning of Deep Freeze II, the existing communications building was extensively altered and became the receiver building. A new transmitter building was erected about a quarter of a mile away from the receiver building. In the receiver building, the old communication office and the communications officer were moved into the room formerly used for amateur radio. The entire office previously used for crypto center and communication office was removed. The cabinets containing the receiver patch panels speakers, and teletype converter/compensators were replaced with one which was placed between two operating positions. The three transmitters were removed. Two additional CW operating positions were installed giving a total of five, and all the operating positions were revised. The electronics repair shop was relocated.

The size of some of the new transmitters was such that it was necessary to construct the building around them. The floor was laid and the transmitters then positioned. By 1 March 1957, the building was complete except for the roof. To prevent snow from entering the building and interfering with the installation of the transmitters, a false roof was constructed of 4-foot by 8-foot plywood panels covered with tarpaulin.

On 14 May 1957, NAF McMurdo experienced a blizzard and the false roof was partially blown away and snow entered the transmitters. Fortunately, however, the equipment was off at the time. It was not until

the 31st of May that the equipment was dried out. On the 1st of June the equipment was again ready. The personnel in transmitters spent the next few weeks improving working conditions in the building. Fifty-pound CO_2 fire extinguishers were obtained from VX-6 and were installed in strategic locations, and wiring on the equipment was continued.

Little America

The electronics building housed all aviation communications, electronics shop, navigational aids, the air operations office, search and rescue center, spares storage, cooking facilities, and a small bunkroom. On the south end of the electronics building was the old URN-5 homer shack which was used to house the 50 hp frequency converter necessary for the operation of the TPS-1D surveillance radar and certain test equipment. The air operations office and search and rescue center, an 8-foot by 16-foot plywood enclosure, also contained the electronics technical library and the Kiel Field officer's bunk.

It was necessary to locate the new transmitter building adjacent to the message center as a result of the lack of control cable or any substitute, although a location permitting a wider separation of transmitters and receivers would have been preferred. The situation could have been alleviated considerably by a wide separation of receiving and transmitting antennas, but the shortage of antenna wire and coaxial cable did not permit fulfillment of this objective. The final installation operated very well, however, and without significantly detrimental local interference except during times when propagation conditions were marginal. The proximity of transmitters to receivers permitted a more efficient utilization of the available communications personnel; the ET's could d easily man the transmitter building and execute their other functions in the message center and around the base concurrently or on short notice. A remote location would have produced extended periods of isolation during heavy storms and would have required the assignment of at least one of the RM full time to assist the ET's.

The buildings were specifically located so that the back bulkheads of the message center and the transmitter building would become bulkheads for a necessary enclosed storage area between them, using a minimum of scarce construction materials. The exhaust fans from both buildings heated the storage area as well. The orientation of the transmitter building at a 90° angle from the message center provided maximum accessibility for transmission lines from the transmitters to the antenna farm. Basic construction of the building required five days and several evenings. Berthing the ET's in the transmitter building insured maximum effectiveness of personnel utilization and eased the base housing conditions. A phone to the message center was installed. A tarpaulin was placed over the transmitter building in an attempt to minimize the water leakage from melting snow and ice during warm weather. Two leaks did

develop, however, causing shorts in the 431-D and one TBM transmitter before being noted and corrected. Water-tight buildings are essential in the antarctic especially where electronic equipment is housed.

Wilkes

The communications building was sited on the outer perimeter of the base. However, this was near the supply dump, fuel dump and garage. This caused heavy vehicular traffic within 25 feet of the building with subsequent strong radio noise interference. Location of the fuel dump within 50 feet of the building is a fire hazard due to the possibility of radio high voltage arcs caused by transmitting equipment. It is recommended that future communication buildings be located on base perimeters at a point subject to a minimum of vehicular ignition interference and that fuel dumps be located well clear of radio transmitting apparatus.

The building and space assigned were adequate. It is recommended that only communications equipment be installed on the roof of the building and that every precaution be taken to insure a water-tight roof. A leaking roof was a serious problem and required constant attention.

SCIENTIFIC BUILDINGS

McMurdo

Aerology Building

The aerology building was situated thirty to forty yards from the other buildings in camp in order to have an unobstructed view when making observations. This, however, was limited by the range of hills extending from 330 degrees clockwise to 150 degrees making it impossible to observe phenomena below four degrees elevation.

During the winter night it was extremely difficult to make observations of aurora due to the camp lights. While the brighter displays were visible after a period of five or ten minutes of observing, the lighter displays were visible only if the observer went a few hundred feet from camp.

There were two heaters located in the building; a Jet heater and a Preway heater. It was necessary to use both of these. During normal weather with prevailing easterly winds, the Jet heater was used with excellent results. With the onset of a blizzard, which always had winds from a southerly direction, it would be necessary to switch to the Preway heater due to the position of the stacks. With this combination of heaters no problems were encountered with fumes inside the building.

Due to the large amount of equipment and material it was necessary to make use of all available space for storage. Shelves were installed in the entire overhead, lowering the overhead about a foot. During the winter months, it was possible to use the space designed for AirOps for storage, but from September to March this space was not available. Some of the equipment and material should be stored inside as best results are obtained from such items as balloons and batteries when stored at room temperature.

During the winter months ice would form on the inside of the shelter located on the roof of the building. From September to December this ice would melt when the sun was shining on the shelter and the water would run down into the office, creating quite a problem. Chipping off the ice by lightly tapping it with a hammer solved this, but would have to be done often as the ice would reform.

Recommendations. Install at least four windows. Locate the building with an unobstructed view. Make available more inside storage space.

Inflation Shelter

The location of this building was excellent as evidenced by the fact that only two releases were missed due to high winds. It was situated on the side of a hill with the door facing downhill in a north northwesterly direction. Although many bad falls were made on the rough terrain around the building when releasing balloons, no one was seriously hurt.

During periods of moderate to heavy blowing, much snow accumulated inside the building creating quite a problem when the heat was turned on. The melting snow would mix with the caustic soda and aluminum chips kept in the building, resulting in generation of hydrogen gas. It would then be necessary to dispose of the affected chemicals. The biggest source of snow was through the doorway which had to be opened a number of times during bad weather, but there was much accumulation even with the doors closed. This was cut down little by little as weather stripping was placed where needed.

Many premature bursts occurred taking the balloon through the doorway, which was too small. The balloon was held as close to the floor as possible, leaving a few inches clearance on the sides and sometimes none at all on top while going through the doorway. Covering the sides with cloth for the balloon to rub on cut down the number of premature bursts.

There was no way to control the doors and, as a result of this, one man received a fractured skull and another was slightly hurt when the doors got out of control during periods of high winds.

Chemicals and helium were kept alongside the buildings as there was only enough space inside the building for a one-month supply.

In November a Jet heater replaced the Herman Nelson heater making it practical to store water in the building. Ten gallons of water were carried from the galley for each inflation, thus requiring at least 20, and sometimes as much as 50 to 60 gallons, for each 24-hour period.

Recommendations. Smooth out the area on all sides of the building for a distance of about 50 feet to eliminate accidents. Increase the size of the doorway to eliminate premature bursts. Install some sort of device on the doors so that they can be controlled at all times. This could be accomplished with the type of door that runs up into the overhead instead of opening out sideways. Install a smaller door on the east side of the building. This way the large doors would have to be opened only for the release of the balloon, thus eliminating snow accumulation and possible accidents from swinging doors. Install a 100-gallon tank inside the building for water storage. The ideal inflation shelter for areas such as the antarctic, where moderate to strong winds predominate, would be one made of some light material built in such a way that it could be turned manually, thus providing a way to have the doors on the leeward side no matter what direction the wind is blowing from. A square shape with twenty foot dimensions and a roll-up door at least twelve feet wide would be large enough. The generator could be located in another building and heat would be necessary for this building only. The money saved in equipment and material (balloons, instruments and helium or hydrogen gas) would more than pay for such a building.

Inflation Shelter Heater Building

This building is located about 10 feet behind the inflation shelter with a wood duct connecting the two. Heat is fed through this duct into the inflation shelter. The building was built only large enough to hold a heater and had one door on the west side. The door was blown off twice and at other times snow accumulated to the overhead inside the building, but after closing off this door and installing one on the east side, these problems were eliminated.

A Herman Nelson heater with an electric motor supplied the heat; fuel was stored outside and hand-pumped into the heater as required. The heater was turned on only during inflation periods, thereby eliminating some of the melting inside the inflation shelter and reducing the fire hazard. It was left on during one storm to eliminate opening the door,

but this caused too much melting in the inflation shelter and as a result the doors were frozen shut. This required three hours of chipping to get the doors open, and by this time it was too late to make a release.

A Jet heater with thermostat control replaced the Herman Nelson in November and should prove much more practical.

Shelter R18S1795

One shelter was located outside of Aerology and another on the runway. They were secured with cables and required occasional checks to see that they remained secure. During the summer months, at one time during the day, the sun would be shining directly at the door resulting in fluctuating temperatures when the door was opened. Installing a second door would eliminate this.

South Pole

Science Building

The science building housed the ionosphere, geomagnetic, seismology, aurora, and glaciology spaces, IGY and Navy office spaces, and sick bay. Basic space allotment was adequate for all purposes. The two major problems encountered with the inflation shelter were heating and the release of ballons through the overhead hatch.

The 8-foot square overhead release hatch was only barely large enough for the Rawin Sonde balloons. Windbreaks installed on the windward sides of the building made releases possible under almost all conditions. However, a larger roof hatch about 10-foot square would be highly desirable, and is recommended. Drift accumulation practically precludes the use of side doors.

The aurora tower presented by far the greatest problem, in connection with the defrosting of the aurora domes. No adequate system had been devised and obviously little or no thought had been given to this problem. The makeshift system finally installed did provide adequate defrosting, but only at the expense of exceptionally high fuel consumption in a building only 8 feet by 8 feet by 20 feet. Though a designed and tested defrosting system was requested, apparently no action was taken. The system used involved two Preway space heaters and five ILG centrifugal fans. One dome had two 1/2-hp fans, a second dome two 1/4-hp fans, and the third one 1/4-hp fan.

It is strongly recommended that an adequate and efficient defrosting system be designed, tested, and procured, with specifications of adequate defrosting at -100 F with 20 knots of wind.

Hallett

Balloon Inflation Shelter

The design of this building was not considered very effective for the type of operations and weather encountered. The overhead release procedure was designed for use in buildings that would be buried in the snow, which caused a considerable amount of trouble. During periods of winds in excess of 20 knots, many premature balloon bursts were caused by the strong eddies around this building. To relieve this situation and permit the successful completion of the IGY MET program, it was decided to construct a walkout release shelter on the lee side of the original building. After the construction of this modification only three upper air soundings were missed due to surface wind conditions.

The generator building was constructed of spare Clements panels, 12-foot panels being used on two sides. The third side consisted of doors made of 3/4-inch plywood. The doors were hung to open outward and could be secured in the open position to act as a windbreak. A small access door was cut through the original north wall to allow entry from the inside of building #6. This structure was not attached to the original building by clips, but was bolted using carriage bolts. When completed this extension was 8 feet long, 8 feet wide and 12 feet high.

Aerological Office

The aerological office was located in the mess hall building and the space provided, though small, was considered adequate. All standard aerological instruments were housed in this office with the exception of the wind mast which was located on the top of the head building, and those instruments that required outside locations (thermometers, hygrothermograph rain guage, and GMD tracking unit).

Shelter (R18S1795)

This instrument shelter was installed in the penguin rookery 60 feet from the east side of the aerological office. No trouble was encountered with it after it was permanently secured to the ground with cables. It is believed that a shelter with two access doors would be more useful in Antarctica, to eliminate the sun shining directly on the instruments during the summers and to allow a possible opening on the lee side during periods of high winds and blowing snow.

Wilkes

It was apparent from the beginning that the overhead release facilities in the balloon inflation shelter would not prove satisfactory during periods of high winds. Releases were extremely difficult in winds of

30 knots and impossible in winds of 40 knots and higher. Releases were made from the station garage on occasions, but this was unsatisfactory due to the direction of prevailing winds and to the close proximity of radio antenna masts. In October, walk-out doors were fabricated on the hydrogen shelter lee side by hinging two complete panels so that they would open outward. No soundings were missed after that time although the wind did not thereafter exceed 50 knots. It is recommended that balloon shelters for future polar operations be equipped not only with overhead release facilities but also with walk-out doors on two sides if possible. It is not believed however, that this will fully solve the problem. The Russian base at Mirny reportedly had a method whereby releases were made in winds of 70 knots and it is recommended that this be investigated.

No provisions were made for water storage in the balloon shelter. Three water tanks were installed in the shelter with a total capacity of 540 gallons. By using these tanks snow could be melted and an adequate water supply maintained for all occasions. This made it unnecessary to water for each sounding. It is recommended that pen points for desk pen sets, stamp pad ink, heavy wrapping paper, masking tape, straight edge rulers and ink eradicator be added to future aerological office equipment. The supply of form WBAN-10B was inadequate and it was necessary to trace forms to finish the program. The office roof leaked profusely during the summer season.

Ellsworth

The whole camp was set up 180 degrees out of phase with respect to the prevailing winds. This resulted in the inflation shelter being set up on the windward or south side of the camp. The design of the inflation building was poor. The only egress for balloon launching was through the overhead doors. These overhead doors had to be managed manually. Any winds exceeding 15 knots turned the doors into man-killers. Once the doors were open the difficulty of launching the balloons was almost insurmountable. The balloon was anchored to the floor of the shelter. The instrument was handed up through the hatch to a man on the roof. At a given signal the balloon was cut loose and the man on the roof waited for the slack to be taken from the train by the rising balloon. As the train became taut the man on the roof released the instrument and the launching was successful.

An intercom system between the aero office and the inflation shelter facilitated the launching of the balloons. Prior to release the speed and direction of the wind was noted. The receiver in the Radome was pointed downwind. Experience dictated the proper elevation angle. Upon release the men would call the directions and angles over the intercom system. The man at the receiving unit would "feel" for the

transmitter as it was borne aloft by the balloon. Once the peak input was reached the receiver was thrown into automatic track and for the rest of the sounding the machine took over.

Wind in excess of 15 knots usually proved disastrous. Difficulty in opening the doors, blowing snow, venturi effect on the balloon as the wind blew across the hatch opening the balloon would bulge out over the combing and burst. If the launching was successful, often the instrument smashed into the Aurora Tower or became entangled in the antenna farm. A successful program was finally achieved by the construction of walk-out doors, but these doors became covered with blowing snow during periods of high winds. Recommend: 12-foot by 8-foot doors of metal. Raised and lowered by chain fall opening to leeward.

Section VI

MATERIALS HANDLING

EQUIPMENT

Inadequacy of equipment was a problem which never ended. Equipment left from Deep Freeze I was worn out. Prior to arrival of the ships in December 1956, operable heavy equipment at McMurdo was limited to one D8 tractor, one HT4 fork lift tractor and four D2 tractors. All of the latter were completely unreliable, and the number of manhours required to keep them running was anything but economical. The four Traxcavator 955's which arrived with Deep Freeze II proved to have an inherent design flaw and to be unsuited for operations on the rough terrain and hard sea ice of McMurdo Sound. Off-loading operations were, on more than one occasion, brought to a complete standstill, with all tractors in the shop for repairs.

Four Pettibone-Mulliken Cary-Lifts were assigned to McMurdo. One was damaged in off-loading. The other three performed well in camp on hard snow and dirt. They were not satisfactory for deep-snow operation. "They will do many jobs an HT4 can't touch."[7] During the summer of 1956-57 all were down save one, and that had unreliable brakes and was considered delicate. It was used exclusively for gathering snow for the snow melters. The main sources of trouble were hydraulic systems, fuel pumps, clutches and brakes. Hydraulic hose replacements were difficult because the hoses were cut to length and had non-interchangeable fittings. Repairs to these machines would have been simple had parts been available. "Ninety percent of all downtime was due to poor operators, improper use of the clutch, no oil in the lift pump, or forcing controls against stops."[7]

One Cary-Lift, made available to McMurdo from the Knox Coast equipment, assisted cargo-handling operations at a critical time and fully proved its value. It was diesel-powered (the others were gasoline). The only difficulty experienced with it was repeated breaking of the brass fuel line, which had a loop in it to take up vibration.

"HT4 fork lifts were kept on the trail most of the time. They worked out very well as prime movers because they had more power and if a crate fell off a sled the fork lift could be unhitched to lift the crate back on."[7] "The HT4 was not completely satisfactory at Little America due

to deep penetration of its standard D4 tracks while maneuvering in snow to pick up a load. They should have LGP tracks in this area."[8]

Conclusions and Recommendations

Wheeled vehicles cannot be used at locations where there is a deep snow cover. Whether there is any advantage in the use of tracked vehicles compared to aircraft for moving materials depends on the time in which the move must be made. Tractors and sleds can move more tonnage but take longer to accomplish the move and depend entirely upon a safe trail being established. However, tractor swings can move in weather that is not suitable for flying and can haul heavier and bulkier articles than aircraft can.

After a station is established, re-supply could be effectively and more quickly accomplished by using a vehicle of the Sno-Cat type. Such a unit would have to be larger and heavier than the existing Sno-Cat (probably 30,000 pounds gross), but employing the track features of the Sno-Cat. Such a vehicle towing sleds commensurate with its size could effect resupply much faster and safer. Where a D8 tractor can move at a maximum of 3 miles per hour, the suggested unit can move between 5 and 10 miles per hour and would exert much less ground pressure and provide safer travel.

A fork lift should be assigned to the supply department on a permanent custody basis. During off-loading operations, two fork lifts, one of which should be a Cary-Lift, should be constantly available to personnel in the storage dumps. "A Cary-Lift mounted on a low-ground-pressure track would be ideal."[9]

OFF-LOADING

McMurdo

Off-loading operations depend upon the following:

a. Distance from shipside to camp

b. Amount of equipment available

c. Condition of ice roads

d. Condition of camp roads and storage areas

e. Amount of fuel hose available

f. Personnel available for a 24-hour unloading schedule

All off-loading of ships at McMurdo was conducted over the ice with tractors and sleds. Weasels and small sleds were used for minor material and personnel. Because of the thickness and normal deterioration of the new sea ice during the summer, no tractor larger than a D4 was used. A D8 was used only on 9 feet or more of old ice. A D4 can handle two 10-ton bobsleds or one 20-ton bobsled fully loaded under the worst trail conditions (i.e., wet snow, potholes, deep ruts and steep grades caused by wave formations in the snow surface). When trail conditions improved, larger payloads could be hauled.

Speed is all important in off-loading at McMurdo. A 24-hour schedule is mandatory. Cargo ships are on strict time schedules and ice conditions constantly hinder and endanger the ships. The faster ships can be off-loaded when they are berthed alongside the bay ice the better it is for the operation, particularly for the safety of the thin-skinned ships. The distance to the point for off-loading will be dictated by where the ice runway is located and by the thickness of bay ice. For planning purposes at McMurdo, a distance of eight miles should be considered.

The speed of the tractors is approximately 3-1/2 miles per hour, so it is imperative to have a sufficient number of tractors available for a cargo ship to continuously off-load two holds. An onshore breeze brings in the ice, so that ships must sometimes stop operations and leave their moorings. A lack of visibility is a justifiable reason for stopping cargo movement. When drivers cannot see the trail or trail flags, they must be directed to stop until visibility improves; otherwise cargo, equipment and personnel may be jeopardized.

A dispatcher or loadmaster was placed aboard the ships being off-loaded. A check out/in procedure was set up at each end of the trail so that personnel and equipment on the trail were known at all times. Two drivers were normally assigned to each tractor on a 12-hour on, 12-hour off basis to assure continuity in maintenance of the tractor and sleds. When a driver brought his tractor into camp, he would drop his load, service his tractor, pick up empty sleds and return to the ship. Arrangements for chow would be made for a driver arriving at odd hours. Extra drivers were used as available to make alternate trips or to service tractors while the other driver ate. Radio contact between dispatchers was essential. Off-loading crews aboard ship and at camp scheduled their meals and recreation according to arrival times of sleds as estimated from departure reports.

During the January 1957 ship off-loading of Deep Freeze II cargo, most of the cargo, except for drummed POL, was "dumped", not "stacked", in the various caches by category. This occurred as the result of an all-out effort to get the ships unloaded, and not balancing the available manpower.

A petty officer in charge of operations continually checked the trail in a weasel. If a tractor broke down, he dispatched a maintenance crew immediately. A D2 tractor was kept near the ship to move loaded sleds away from the ice edge and to move empties in for loading. When ice conditions were questionable, loaded sleds would be winched away from shipside. Sometimes a tractor with blade would return empty to the ship in order to work on the trail on its way. A well-maintained trail was essential to speed of operations and to the life of the equipment.

There should always be eight to ten more sleds than the total tractor towing capacity. Several loaded and several empty sleds should be located at each end of the trail to keep loading and unloading operations moving. This reduces turn-around time, as sometimes delays in off-loading sleds cannot be avoided. All vehicles on the trail should have survival gear. For short hauls (5 miles), this gear would consist primarily of food and sleeping bags; for long hauls (30 or 40 miles), tents and extra fuel should be included as well as a radio. In December 1955 these precautions saved a tractor train crew operating in the vicinity of Cape Bird, 50 miles from Hut Point.

Maintaining the trail is important. Navigation for this type of operation is strictly visual. Red flags were used to mark the trails, cracks and danger areas. Flags were placed a maximum distance of 150 feet to 200 feet apart. Fluorescent markings were handy during the winter night. These markers reflected when a headlight or flashlight hit them. An aircraft beacon was successfully used to guide survey crews back to camp during the night. Very pistols are handy to have for signaling and for guiding stranded personnel.

Double handling of cargo is slow and should be eliminated if possible. The camp now has four 40-foot by 100-foot buildings for storage, and delivery of supplies to this location has expedited the unloading of cargo. A large area where barrel diesel can be concentrated one tier high would greatly reduce the unloading time. Stocking of barrels higher than one tier causes large snowdrifts and it is not practical for the antarctic. The volcanic dirt is very abrasive and raises havoc with equipment. Also the dust from the volcanic ash can penetrate the seals of the bearings of all equipment and continuous service in washing, greasing and oiling is a must. Tracked Athey wagons are useful in this area where snow and earth are found. Considerable damage to sleds was experienced during Deep Freeze I, as they had to be pulled over earth to certain storage facilities.

Until the roads in camp are properly drained it will be impossible to treat the road surface with either oil or calcium chloride.

Four-inch rubber hose, with quick-connect fittings, is perfect for pumping oil products. The 10,000 gallon tanks can be inserted at any distance and a pump installed to speed up the pumping operation. The hose weighs 75 pounds per 50-foot section and can be easily laid in position with a small group of men. Approximately ten miles of hose should be available at McMurdo Sound.

Little America

In December 1955, the cargo ships were secured to the bay ice some four miles from Little America. The off-loading of supplies was initially an orderly operation, as a temporary supply dump was established on the bay ice approximately 1.9 miles from shipside. Adequate handling equipment, two Cary-Lifts and one HT4, was available. Some three weeks after off-loading commenced, the bay ice started to move out and all cargo was frantically moved to the camp site in less than 72 hours. The demand for a quick turn-around of sleds and tractors forced the unloading at camp site to be disorderly. This lack of orderliness was increased by the lack of proper materials-handling equipment. Only the HT4 could be used for off-loading sleds as the Cary-Lifts could not operate in deep soft snow. The HT4 was only available periodically, as it was required for many other jobs. The result was that many items too heavy to be properly off-loaded by hand were skidded off sleds by manpower or bulldozer, to be moved later when the HT4 became available.

A ramp from the barrier to the ice was ready for Deep Freeze II off-loading, but a tidal crack crossed the path between the end of the ramp and the proposed mooring area at the ice edge. In three days all the bay ice had disappeared, making it possible to unload directly on the barrier. The D8 was used to blade down the barrier edge and level an area large enough to accommodate the sleds. Deadmen were buried for the ships' mooring lines, and explosives were used to smooth the face of the barrier.

As unloading commenced, it was discovered that cargo had to be pulled up the edge of the barrier, since the ship's booms could not swing out far enough. Also, the barrier height of approximately 30 feet hindered boom operations. Heavy deck cargo, such as three Otter aircraft in crates, were winched up by the D8 tractor after the ship had lifted them as high as possible. Two LCM's were off-loaded the same way. One of the first items off-loaded was an additional D8 tractor. Because of its 35-ton weight, the tractor was winched from the ship's deck to the barrier over the Balk bridge. As off-loading proceeded, four D4 tractors, eighteen weasels, six IGY Sno-Cats and ten 10-ton sleds were off-loaded. The off-loading potential was thus greatly increased.

After all equipment was ashore, it became apparent that some other method must be devised to bring ashore the general cargo. A housefall was rigged, using the D8 tractor with boom for attaching the sheave. Then the cargo was loaded directly upon the sleds without any hauling from the barrier. Stormy weather hindered ship off-loading from time to time.

During the first week of November 1957 all explosives and demolition equipment was dug out and made ready for use in blasting and preparing an off-loading site for Deep Freeze III. In the eventuality that the bay ice should go to sea or be unsafe for unloading, a barrier site was selected as an alternate unloading area. An area 600 feet long and 100 feet wide, in the same relative location as the previous years' unloading site, was staked out and bladed.

In the eventuality that the bay ice could be utilized during off-loading, a ramp was made by walking a D8 on the ice, first alone, then towing two 20-ton sleds. Periodic test borings were made to ascertain the ice thickness (approximately 9 feet of solid ice) and special vigilance was given to the cracks to detect any signs of "working".

Conclusions and Recommendations

All off-loading equipment should be assigned directly to the Supply Department together with permanent drivers. As drivers become familiar with the dump site layout, unloading proceeds at a much faster rate. The HT4 tractor with forks is considered too slow and rigidly built to haul over ground, but it worked very well in snow. It has been suggested that all cargo should be strapped and banded to 4-foot by 4-foot pallets and handled by fork lift and crane. Additional fork lifts were provided as requested, but no cranes were received.

Although the desire to off-load the ships as expeditiously as possible is understood, it must also be realized that the rapid movement is at the expense of proper segregation and storage at the supply dumps. Experience during the unloading phases of both Deep Freeze I and II indicated a need for more effective coordination between ship and shore groups. Emphasis should be placed on allowing the wintering-over personnel sufficient time to maintain order in supply dumps and avoid possibilities of loss of essential materials. Unloading should be executed in an orderly manner and materials not be dumped.

Hallett

The initial off-loading and resupply of Hallett Station was accomplished as an amphibious operation. The cargo was loaded directly from the ships onto trailers in LCM's. The trailers were pulled from

the LCM's by heavy equipment and towed to the unloading site. All supplies, other than POL, were moved directly to the camp area to be sorted by categories. The POL products were stored in a fuel dump. During the operations more emphasis was placed on speed than the location and sorting of supplies.

Wilkes

After selection of the base site, a landing party was put ashore to blast a ramp through a small ice barrier and to set up a supply dump area. The area was organized by placing flags attached to bamboo poles into the ice in the desired pattern. The flags carried letters corresponding to material categories. All material was off-loaded with the LCM's of the cargo ships. A rubber-tired wagon was placed in an LCM, loaded with materials, and taken onto the ramp. There, either one or two 955 Traxcavators, as needed, would haul the wagon out of the landing craft up the ramp to the appropriate area for unloading.

Personnel, consisting of the construction crew, the wintering-over group, and portions of the ships' crews, was organized into two 12-hour shifts for the unloading work. As many as 40 trips could be made by the LCM's during a 12-hour shift.

Ellsworth

At first it appeared that it would be possible to discharge cargo from both forward and aft holds simultaneously. This would have permitted unloading according to a predetermined plan. However, the portion of the shelf above the water line at the unloading area was a soft snow cover which progressively failed and broke off under hard usage. Very early in the unloading operation the usable unloading area decreased to the extent that it was possible to work only two adjacent hatches simultaneously. On 1 February a thirty- by ninety-foot section of the shelf broke away under the weight of a D4 tractor and dropped the tractor over the edge of the shelf. Sleds were of necessity taken alongside individually. This was accomplished by bringing the sled near the ship with D4 tow cable, and using a whip line from the ship to position the sled alongside. Unloading of all material was completed in 13 days. Three D4 tractors were used at shipside to spot sleds under the cargo booms and to hook up sled trains. The remaining five D4's hauled sleds and unloaded and spotted material at the base site as necessary to keep a balance between unloading and construction. The two D8's were used almost exclusively to haul sleds, as they were capable of pulling five loaded ten-ton sleds upgrade to the shelf plateau. The D4's could pull two lightly or one fully loaded sled up the grade. Except for the lack of a swinging boom crane, the kind and quantity of tractors for hauling were properly chosen for the job.

A D4 tractor equipped with fork attachments did an excellent job of handling the packaged material. D4's equipped with boom and barrel chimes were used to handle the many thousands of barrels of fuel. Where the tractors were constantly working in the same area handling barrels, it was a steady battle to keep them from sinking into the extremely soft and powdery snow. Also, the action of tractors in swinging the booms into place was irregular and jerky, through no fault of the operators. For future operations, a piece of equipment with a swinging boom is highly recommended, both from the standpoint of speed of operation and safety of personnel stacking barrels. Such a piece of equipment could have many other uses during construction.

SURFACE TRANSPORTATION

Safety Precautions

The following safety precautions were promulgated at McMurdo for the observance of all hands. They are generally applicable to all antarctic areas.

1. Equipment will not work near the edge of ice. Ice might calve, resulting in loss of life and equipment.

2. Loaded sleds must be moved from the ice edge as soon as possible. Temporary dumps will be located at a safe distance from the ice edge. Sleds should be winched or towed a distance from the ice edge rather than being pulled directly, and the tractor or weasel should remain a safe distance from the ice edge.

3. All equipment working in isolated locations will be fitted out with sleeping bags, small stoves, fuel, and rations for one week for each man. It will be the drivers responsibility to insure that such emergency equipment is in the vehicle.

4. The CTF 43 communications plan will be strictly adhered to for safety of all concerned.

5. All vehicles operating in isolated locations will work buddy system. "Isolated locations" under many circumstances can mean a hundred yards or more.

6. If vehicles fail in isolated locations and a path to safety is not ABSOLUTELY certain, radio for help and STAY WITH THE VEHICLE until help comes.

7. If caught blind away from camp, it is better to dig in and wait the storm out than to move blindly.

8. Wear sun glasses at all times when out-of-doors. Equipment drivers shall also wear sun glasses when driving.

9. Insure that someone knows where you are at all times. Never walk alone except in dire emergency. A good habit to get into is to tell a buddy that you are going somewhere and that if you don't come back by a given time to come and get you.

10. As a matter of sanitation, a head will be built as soon as possible. Do not urinate or defacate except in designated areas. All areas designated for snow melters must not be polluted.

11. Emergency warning signals while ships are moored will be as follows:

    a. Three short blasts of whistle repeated means that a blizzard is three hours away. Commence securing equipment.

    b. Five short blasts of whistle repeated means all hands return to ship or to campsite.

    c. Seven long blasts of whistle repeated means all shipboard personnel return to ship for getting underway.

    d. Additional signals may be devised by competent authority.

Trail Operations

McMurdo

The trail operations around McMurdo were conducted entirely over the McMurdo Sound sea ice. As such, there was no requirement for crevasse detectors. Cracks in the sea ice were normally open, or if snowed over, were usually visible. The primary difficulty was maintaining a check on ice thickness. In spite of constant precautions, two lives were lost because the ice gave way under equipment. The primary trail operations were in connection with off-loading the ships. Here, as with the ice runway, deterioration of the surface due to heat was a major problem. In October 1956, the U.S.S. GLACIER moored at a point approximately 12 miles from Hut Point. A trail was investigated and flagged. At shipside the ice varied between 4-1/2 and 6 feet thick. It was snow-free, but very soft and logy. At no point on the trail was the ice thinner. It was therefore considered to be safe enough for the D2 tractors and

20-ton sleds. When loading sleds at shipside, the ice was observed to deflect when the net load on a 20-ton sled reached about 12 tons, and therefore loads were restricted to this amount.

Trail operations during this phase were trouble-free except for one severe blizzard and for snowdrifts. Drifting was particularly troublesome at tide cracks. While the cracks were usually tight and bridging unnecessary, pressure ridges formed at the cracks and trapped the snow. The D2's were too light to pull the 20-ton sleds through the snow and inevitably bogged down. Additional tractors were required to get the sleds through the drifts. For this reason, the D2's were judged unsuitable for such operation.

When the task force arrived in December, the ships were moored 17 miles from Hut Point. However, the ice at this point had deteriorated to 2-1/2 feet of thickness and was badly cracked. The icebreakers cut a channel to a point eight miles north of Hut Point and off-loading commenced at this point. By this time the surface of the ice had suffered from the continuous warm weather of November and December. From the edge of the old sea ice south toward Hut Point, a distance of about 5 miles, the surface was covered with melt water pools and potholes. Tractors and sleds took a terrific beating as they plunged into holes three and four feet deep. In an effort to find a better surface, the trail was soon spread over an area half a mile in width.

The trail was examined daily and borings made to determine ice thickness. As large melt ponds developed, bulldozers filled them with compacted snow. Near the shore line, tidal cracks constantly opened and closed. It was necessary to maintain continuous surveillance of those cracks and periodically blast snow bridges and fill the cracks. Tide cracks which have refrozen are not dangerous but are hard on equipment. They should be filled with snow and compacted. If the cracks are more than 6 inches wide and are wet, bridging should be considered. The most suitable bridges are those that can be quickly erected and moved. They should be as light as possible and reusable. The Army aluminum deck balk fixed bridge was successfully used for long spans and heavy loads. Heavy timber bridges were placed over the most serious cracks. In spite of all precautions, however, tractors did on several instances drop into tide cracks. No danger of losing tractors or personnel existed since the cracks were too narrow, but each incident did delay operations until a D8 extricated the encumbered machine.

The most serious problem during the month that was required to off-load the ships was equipment breakdown. It was definitely accentuated by the almost impossible surface of the trail. Toward the end of the off-loading operation the temperature dropped sufficiently to permit effective maintenance of the trail. At this time, breakdowns noticeably decreased.

Most ships are off-loaded during the summer cycle, when ice roads deteriorate rapidly. Therefore, roads must be maintained constantly to insure maximum equipment speed with minimum breakdowns. An LGP D8 tractor can maintain ice roads fast and it is well adapted for work on bay ice. Much contamination of roads can be traced to the grousers of the dozers depositing dirt on the roads. It is unavoidable but can be corrected by proper maintenance.

Little America

"Surface and hauling conditions at Little America are such that wheeled vehicles are useless. The consistency of the snow varies in different areas. Along the barrier edge it is like coarse sand and forms a crust at different levels. In some spots this crust will hold the weight of a man. A D8 tractor with low-ground-pressure track penetrates about 2 to 3 inches and a loaded 20-ton Otaco sled will penetrate about 3 to 5 inches. Inland about 10 to 15 miles the snow is very fluffy and has no crust. A man will sink into it 6 to 12 inches. A D8 tractor will penetrate about 6 to 8 inches and a loaded 20-ton Otaco sled will penetrate about 12 to 18 inches. It is almost impossible for a second D8 tractor with two loaded sleds to follow in tracks that have been made by a first D8 with two loaded sleds. The problem of tractor penetration on the trail between the ships and campsite was solved by continually grading the trail. This operation tied up two D8 tractors for 24-hours a day during the unloading period."[8]

Tractor Train Operations

Little America to Byrd

The sustenance of Byrd Station depends primarily upon resupply by surface transport. Therefore, a heavy tractor swing was assembled at Little America in November 1956. The swing consisted of six trains and one weasel. Each train was composed of one D8 LGP tractor pulling two 20-ton Otaco sleds. Each train carried 918 gallons of diesel fuel, 118 gallons on the tractor main tank and 800 gallons in a tank mounted on the front of the sled directly behind the tractor. Ten of the sleds carried materials necessary to construct Byrd Station and the remaining two sleds carried a sleeping and a messing wanigan respectively. A total of four buildings plus all collateral gear was hauled.

With the establishment of a trail to the Rockefeller Plateau, the swing departed Little America on 5 December 1956 with 19 men. The personnel was divided into two watches which ran from 0700 to 1900 and 1900 to 0700. Meals were served at each stop for changing the watch, and coffee and sandwiches were delivered to each tractor while underway. Except for breakdowns no other stops were made during watches. Shakedown troubles were experienced the first day out. Tractors were

frequently bogged down because half of the personnel were inexperienced. However, this situation resolved itself as experience was acquired and personnel became accustomed to tractor train operations.

The fuel transfer pumps, mounted on the tractor catwalks, froze making it necessary to transfer fuel from the 800-gallon tanks to the tractor fuel tanks by hand pump. To correct this, the pumps were heat-soaked and wrapped with rags.

On 9 December the swing arrived at the beginning of the crevasse area which extended for 7 miles to the foot of the Rockefeller Plateau. At this point, the swing was broken up and one sled at a time crossed the crevasse area. The remainder of the swing crossed at 8-hour intervals. The last train over brought the wanigans. The first day on the plateau the generator in the messing wanigan developed a metal fatigue crack in the engine block. A 5kw gasoline-driven generator, part of the cargo on the swing, was placed on the luggage rack on the side of the wanigan to provide the necessary heat, light and snow-melting facilities.

The weather continued warm and the trail was soft in spite of the constant increase in elevation each day. Tractor penetration varied between 6 inches to 1 foot and sled penetration varied between 1 and 3 feet. On 13 December at the 225-mile mark, the swing was stopped when a push rod in a tractor engine broke. With the repairs completed, the train got underway but was halted again at the 241-mile mark on 14 December when a track-carrier roller split on the same tractor. Another roller was flown in on 16 December, installed and the swing resumed its travel to the fuel cache established by aircraft at the 250-mile mark. Refueling took approximately 3 hours and required 6400 gallons to top off all tanks. The trail remained soft and constant watch was necessary to prevent ice building up on the track-carrier blocks and exerting severe strain on the track. Past experience had shown that when the build-up became too great the strain caused the track-carrier block to carry away from the frame at the point where it was welded. Delays were also caused by fuel pumps and filters becoming clogged with dirt from the fuel; in some cases water in the fuel caused delays while the water was purged from the system.

Different methods of arranging the swing were tried. One train following in the tracks of a preceding train was not successful. The second and third trains caused deeper ruts in the trail and following trains were slowed or bogged down completely. The best method found was to have each train lay over one track width from the preceding train.

The terrain consisted of a series of gentle slopes leveling off then rising again. This rolling terrain was prevalent all the way, eventually reaching an altitude of approximately 5000 feet. At the 500-mile mark the snow crust was slightly harder and the swing could get into fourth gear some of the time. The site of Byrd Station, 645 miles from Little America, was reached on 23 December.

The swing departed Byrd Station on 27 December 1956 after all mechanics and drivers had thoroughly checked all equipment. The track-carrier supports were left off to prevent snow from building up on the track-carriers. This proved to be quite satisfactory on the return trip. The swing was under way until 28 December, when it was halted for the first 20-hour check. Such checks were carried out regularly. The train operated normally in fourth gear until 30 December, when the right rear track-carrier support broke on one of the tractors. Radio communications with Little America requested a welder be sent to the swing at the 275-mile mark from Byrd Station. During the wait for the welder, all the machines were given a complete 240-hour check. An R4D arrived with the welder on 31 December 1956. Work on the track-carrier supports was completed the same date. After traveling 5 miles, another support broke on a second tractor. While this was welded all the others were inspected and breaks were found on two other tractors.

The fuel cache at the 250-mile mark from Little America was reached on 3 January. All refueling operations were completed in three hours and the train resumed its operation. That night the swing arrived at the crevasse area. The tractor with the two wanigans crossed the area first. The last tractor and sleds cleared the area approximately two hours later.

The swing was under way about 12 hours when three tractors became stuck in soft snow. This was the worst penetration encountered. Previous maximum penetration had been approximately 14 inches, while this was slightly over 24 inches. Within 45 minutes, tractors were clear and the swing resumed operations. On 5 January the first whiteout occurred that was dense enough to halt operations. The train was delayed for nine hours. The swing returned to Little America late on 6 January 1957, having covered a total of 1290.6 miles.

During Deep Freeze II two round trips were completed over the 645-mile snow highway, each carrying approximately 200 tons of cargo. The first, consisting of seven LGP D8 tractors hauling a total of twelve 20-ton sleds and two wanigans, took 31 days with a three-day off-loading period at Byrd Station. The second, of seven LGP D8 tractors hauling ten 20-ton sleds, three 10-ton sleds and two wanigans, took 38 days with a four-day unloading period at Byrd Station.

The two-echelon formation is most ideally suited for such long trail operations. This consists, in the case of a seven tractor operation, of four tractors abreast with about 50 feet between them, followed by three tractors abreast about 150 feet behind. This rear echelon tracks in the undisturbed lanes and forms a compact, easily controlled unit.

The system of carrying bulk fuel in 800-gallon tanks and pumping it into the tractor fuel tanks by aircraft-type catwalk-mounted transfer pumps is most satisfactory. With a system of quick-disconnect fitted hoses, the fueling can be accomplished while underway. Although the train is capable of carrying enough fuel to be self-sustaining, this is not economical for reasons of limited cargo space. For this reason, caches were set up along the route. These caches consisted, for the most part, of fuel in rubber tanks varying in capacity from 900 gallons to 10,000 gallons. Transfer of fuel from these tanks to the 800-gallon tanks was accomplished with the use of a 50-gallon-per-minute gasoline-powered pump. The few caches near Little America consisted of 55-gallon drums which were not as satisfactory because of difficulty of pumping. The procedure of pumping, picking up the suction hose, and inserting it in one drum after another causes the pump to lose prime, and time is lost. When pumping from the rubber tanks, however, this problem did not arise. In addition, transfer of bulk fuel to the caches by aircraft is a most expedient method.

Wilkes

Wilkes tractor-train operations were extremely limited. The 955 Caterpillar Traxcavator worked well as a prime mover considering its low power. Three trips were made in support of the Wilkes icecap Station located 53 miles inland. No failures of either the tractor or the sleds were experienced on the trail. The tractor, operated in second and third gears, averaged one mile per gallon of fuel on the ascent to the 4000-foot elevation of the station. An average speed of 3 mph was maintained. On the unloaded return trip, the tractor was operated in fourth gear, the consumption of fuel was halved and the speed doubled. Total distance traveled was 318 miles.

The loads carried ranged from 32 loaded drums of POL and 100 empty drums for use as trail markers on the first trip, to 60 full drums of POL on the last trip. The first load required two 10-ton Otaco sleds and the others used only one.

AIR TRANSPORTATION

During the summer flying period (1956-57), over 650 tons were effectively delivered to South Pole Station and 195 tons of diesel fuel were delivered to Byrd Station. This was in addition to innumerable flights by AirDevRon Six R4D's to deliver and pick up personnel at both South Pole Station and Byrd Station. Beardmore Station was established, supported and evacuated by air.

Airdrop Operations

The total amount of tonnage the Air Force could deliver was limited by the amount of hardware for airdrops and the supply of aviation gasoline. These were expended in the establishment of Beardmore and Pole Stations and additional drops made at Marie Byrd Land. Hardware for Deep Freeze III was then called into play, but flying was restricted for a long period until more avgas was obtained. The total tonnage figures were reviewed many times to eliminate unnecessary material. Lumber and POL accounted for a great deal of tonnage.

Because of the requirement to airdrop all equipment for the establishment of the South Pole Station, many changes had to be made in the equipment to prevent damage and to bring the overall size of some pieces within the drop limitations of the C-124 aircraft. Maximum dimension limitations were: length, 144 inches; width, 80 inches; height, 106 inches. Maximum weight limitations were 7-1/2 tons gross.

McMurdo

Experimental airdrops of both rubber and metal drums containing 50 gallons of diesel were carried out by helicopter at McMurdo. A speed of 100 knots was maintained and the first series were dropped from 200 feet. All containers burst on impact. Subsequent tests from 50 feet were very satisfactory. No ruptures occurred although there were large depressions on one side of the metal drums.

Preparation for Deep Freeze II and III airdrops began in August 1957 at McMurdo. A space at the northwest corner of the parking lot was leveled off to store supplies for the drops. Drummed POL was taken to the storage area at the runway by a crew of four or five men. All material and equipment received from New Zealand was off-loaded into the runway storage area and later packaged by Air Force personnel. All food, equipment and material that was already in camp was packaged there by Air Force personnel, then moved to the runway. Equipment used to load and unload aircraft and sleds consisted of a D4 with chimes or forks and a Cary-Lift with forks. Two pieces of equipment with drivers were required at the runway 24 hours a day throughout the airdrop phase of operations.

Byrd

Airdrops began 10 February 1957 and continued for two weeks at a rate of three or four drops per day. Recovery was with all available hands in two groups working in 12-hour shifts. The digging-out, following chute failure (approximately 16 percent) and the separate handling of drums, imposed strenuous exertion and prolonged exposure upon the men.

During October more efficient recovery was possible, using two crews, each composed of a driver and two helpers. By retaining the POL drums in their packs, a crew could cache a Globemaster load of 64 drums in four hours. Conex boxes of provisions were towed into the station area. From late October to mid-November seven Globemaster loads could not be recovered due to D8 winch failure. The duty crew flagged each crater made by the dropped material as a precaution against blowing snow filling the crater, a common recovery difficulty in the February airdrop operations.

The drop zone was marked by fifteen empty fuel drums laid on their sides in an "X" pattern. On two occasions, in periods of bad weather and low ceiling, planes used this target for radar drops. One drop was excellent, the other fair. No planes of this period failed to find Byrd Station, although two planes traveling in company were unable to locate the base in the previous period of drops. All planes returned safely to McMurdo, though on several occasions C-124 aircraft lost an engine en-route but continued to Byrd and completed their drops before returning.

An improved base interior communications system in the Aurora tower served as the observation point and made closer coordination possible. The observer could relay almost instantly to the aircraft the accuracy of the drop, the number of packs and total that opened, and also control the recovery crew standing by outside. In cloudy weather the observer could aid the plane in locating the station by the proximity of the engine noise. On one occasion the observer could see the plane when the plane itself could not find the base.

South Pole

An analysis of Deep Freeze I and II airdrop operations at the South Pole shows that once airdrops are controlled from the ground, so that they are not so widely dispersed, it takes an average of 18 to 19 man-hours with a D2 and a weasel to pick up, load, drag back to camp, and unload one C-124 airdrop. Material such as bulk lumber, which is free-fallen and consequently scattered, required more than this average figure. A payload, excluding rigging gear, averaged about 23,000 pounds. The fastest material to retrieve is that which can be handled by cutting off a chute, hooking onto the risers with a shackle and dragging it into the camp. A weasel can drag two fully loaded A-22 containers about 125 cube and 3500 pounds total. A D2 can drag almost anything that can be dropped except a full platform of 24 barrels of POL (11,500 pounds). To retrieve the POL, the top layer of 10 or 12 barrels was rolled off the platform onto a low drag and the drag and the platform, each weighing about 6000 pounds, were pulled back separately.

A crew of from four to eight men worked on retrieving, depending upon the type of material dropped. To prevent loss, all material was retrieved as it was dropped. Streamers buried themselves in the snow and were lost easily if not dug out immediately. Eighteen man-hours per planeload was the average time for digging out streamed-in material.

Most of the streamers were dug out with the blade of a D2. POL that streamed in from 1000 to 1200 feet was demolished about 75 percent of the time. Four to six barrels could be salvaged from the twenty-four on each platform that streamed in. Barrels that fell free from low passing aircraft were demolished about 70 percent of the time. They were 16-gauge barrels with 52 to 53 gallons each. Acetylene was one of the important items airdropped at the Pole Station.

During Deep Freeze II and III for airdrops at the Pole Station, when winds were over about 10 mph, a crew was stationed downwind of the drop zone in the weasel to cut the parachutes free from the containers as soon as they landed. This system worked very well, even though the drops were often dispersed over a considerable area. Inaccuracy in dropping was often a problem. Some plane crews obviously made every effort to drop on the tee, but others appeared more anxious to complete the drops as rapidly as possible than to strive for accuracy. It is highly recommended that an Air Force drop controller be sent in to supervise and coordinate drop activities. This was done in 1956, with very good results, but was not done in 1957, though an Air Force drop controller was requested.

Free-fall or streamed-in material was dug out as rapidly as time and equipment allowed. Much material was thus salvaged, though items such as fuel were not worth digging out, as nearly all barrels burst. Accurate manifests should be provided so that ground personnel may know in advance exactly what each plane has aboard and the order in which it is to be dropped. This would enable personnel to know in advance whether free-fall or streamed-in material might be salvagable, or whether it would be an obvious loss.

Air Evacuation

Air evacuation from the South Pole is possible only during the summer period of September to March. The first and last months of this period can present weather problems which make flying impossible. During Operation Deep Freeze II the R4D's and P2V's operated from November 20 to February 12, a period of only eighty-five days. The only problem of any magnitude is the possibility of a plane crash at a distance from the station. In this case, emergency medical gear, sleeping bag, and Coleman stove would be taken on the one-ton sled, together with such survival gear as the distance required. It is felt that the temperatures on the Polar Plateau would preclude the possibility of doing anything but first aid; but it is recommended that shovel and ice saw be included in the

equipment in case it should become necessary to dig in for a longer stay. The snow in the immediate vicinity of the South Pole is of good quality for cutting blocks, which would improve the insulation of an emergency facility.

STORAGE

McMurdo

Open Storage

At McMurdo a permanent supply dump was established at the outset and in the long run this saved many man-hours and enabled distribution of most departmental supplies prior to the winter night setting in. The dump was laid out in 10-foot rows, 35 feet between rows, with the material in alphabetical categories. This allowed plenty of room for equipment to maneuver and allowed a double row of material. All aviation material was stock-piled in one place and segregated toward the end of the unloading period. All fuels and lubricants were stored on the hill about a quarter of a mile from camp. Pole Base material was not segregated during the off-loading. After completion of the building program at McMurdo, The Pole material was assembled by departments concerned for inventory and packing prior to airdrop. Working parties generally varied between five and eight men, depending upon equipment available.

Conclusions and Recommendations. Open storage should be kept to a minimum. Material that is kept outside is not readily available and requires a great expenditure of energy to dig out of drifts in the most ideal cases. If material must be kept outside, it should be stored on a level or high spot, never in a depression. It should be arranged in rows not more than 10 feet wide and 10 feet high, with a minimum of 45 feet from center line to center line of the rows. This allows accessibility by all equipment. Rows made perpendicular to the wind will normally cause drifts to form on only one side, allowing access on the other side. All material should be palletized for the use of material-handling equipment. The storage area should be equipped with a means of lighting. Floodlights (aircraft beacon in one instance) at McMurdo were indispensable during the winter night. The floodlight trailers brought by Deep Freeze II should be helpful if they stand up.

Covered Storage

Covered storage for the Supply Department at McMurdo in 1956 consisted of one inadequate Quonset hut for provisions, one Quonset hut for ships store and, on a part-time basis, the parachute loft. A portion of the photographic storage Quonset was also allocated to the Supply Department. It is strongly recommended that a 40-foot by 100-foot Butler building be

provided for Deep Freeze III provision storage. During the summer months when the stocks are nearly depleted, this building could serve for other supply functions. The parachute loft is an excellent work area during the winter. It allows the men to work out of the wind in a relatively warm space, as Herman Nelson heaters quickly remove the chill. It is ideal for packaging and preparation of airdrop material, because it is accessible to material-handling equipment. It is also an excellent parking space for weasels and small tractors during blizzards.

Little America V

Open Storage

At Little America the material was off-loaded from the sleds and placed in open storage. Due to the time element, the material was dumped with no regard to the problem of recovery after the winter night was over. The bulk of the materials for Byrd Station were stored in the open and many man-hours were used in digging them out when needed.

"Material placed on snow gradually penetrates the surface. In many instances this may be prevented by covering the object with several inches of snow to keep it from absorbing heat. The penetration of building footings, as well as items in the supply area, was observed. This tendency presents quite a problem in a storage area, unless a matting of some type is placed on the snow and the material stored on it. It is felt that landing-strip matting would serve this purpose very well."[8]

Covered Storage

Covered facilities for both Deep Freeze I and II were painfully short. Covered storage areas consisted of wooden framing covered with chicken wire and burlap, similar to the tunnels. The largest area, in the rear of the galley for food storage, was 40 feet wide by 120 feet long. Smaller areas were constructed for electronics and fire-fighting storage. These areas accumulated ice crystals and snow which melted in the antarctic summer, soaking all of the poorly packed boxes which could not be moved. Some among the Deep Freeze I materials were buried under the snow and the chapel was built over them before their location was known. It is believed that they were not critical items, however. There was also a great loss of valuable time wrestling with boxes which had to be moved to be opened or moved for access to other boxes.

In February 1957 the new ships store stock and the welfare and recreation material was moved from the temporary supply depot to the main camp. This material had been plan-packed in 62-cubic-foot boxes in order to utilize them for warehouse construction and self-contained binning. Starting directly behind the third Jamesway hut, a double row (spaced 16 feet apart) of two-high boxes were formed of these uniform packing

boxes. These rows extended about 50 feet behind the Jamesway and formed the side walls of a storeroom. A roof was formed over the space between the rows of boxes with chicken wire and burlap from ships' dunnage. This completed a warehouse for storage of bulk ships store stock, which was inventoried and put on sale. Opening the boxes from the side automatically formed bins in which to store the stocks. This method of storeroom construction was rapid and has since proved very satisfactory.

All other materials were moved to the main base as rapidly as possible, opened, and stored in shops, tunnels and other storerooms built from scrap lumber. The Supply Department operated organizationally as one with non-centralized storerooms, as each department took custody of and was responsible for storage and usage of all materials pertaining to their function. Each department maintained issue records and inventories. Aviation supply was a separate activity under the VX-6 Detachment. IGY supply was also a separate and independent organization under IGY administration. Interchange of materials among the three groups was common and easily effected.

Recovery of Material

The job of recovery was a difficult one, as there was as much as 15 feet of snow cover over some of the material. Photos of the supply area taken in January and February 1956 helped considerably in locating most of the supplies. During the material recovery, a bulldozer was used to clear a path down what appeared to be the edge of the supply area and then, using hand shovels and probing, an item was winched out. The dozer then moved a few more feet over from the edge. Using this method, many thousand man-hours were expended and only a few items were destroyed. The boxes on most items were broken but the contents were still in usable condition. The building panels were the biggest job, as each pallet contained 12 panels and sometimes all 12 were different. Each pallet was opened and a storage area was assigned for each kind of panel. There was a total of 18 different types of panels.

Kiel Field

A tunnel of 2-inch by 4-inch framework covered with chicken wire and burlap was constructed along the northeast side of the aviation maintenance building and part of the generator tunnel. The tunnel measured 15 feet wide, 52 feet long, and 12 feet high. The height permitted the use of the D4 cat, with forks attached, for moving heavy gear. The north end of the tunnel was covered with a tarpaulin which could be raised for easy access. This was kept closed except when moving large equipment and/or using the D4. The other entrance to the tunnel was through a door into the generator tunnel.

Recommendation

Some sort of covered storage, such as a Butler Building or an elephant hut, should be provided to eliminate the unnecessary work and loss of materials.

Byrd

No covered storage was constructed during Deep Freeze I. Covered storage is planned and will be built during Deep Freeze II. The area behind the mess hall was used for food storage and covered at the time with a parachute. Spare electronics parts were stored unprotected alongside building 2 and spare building material alongside building 3. Mechanics spares were placed in bins in the garage.

South Pole

All storage was well planned in advance of actual deliveries of material, and areas were allocated accordingly. IGY material was separated from construction material which was located in and around the garage powerhouse. The material was stored as close as possible to the building in which it would be used. A general dump was established to the grid south of camp. The planning eliminated a multiplicity of handling.

Hallett

All essential material at Hallett Station was eventually stored in buildings or Jamesway huts. The storage plan for Jamesway huts was to allow one hut for each of the following: Electronics and Radio, IGY Material, and Utilities. Two huts were allotted for commissary stores. All other essential material was stored in the building where it was needed. Nonessential material, large bulk items, and some commissary supplies were left in the supply dump with the building material.

Wilkes

A Jamesway hut was used for storage of all spare parts. The metal boxes were stored on shelves, the boxes numbered, and their contents inventoried and placed in cloth bags. The parts were then taken up on Repair Parts Stock Record cards. This was an excellent system and worked very well. However, prior to this inventory the finding of spare parts was a grab-bag affair, as no inventory accompanied the more than 40-odd boxes. Some parts arrived which were unidentified, and since no supply publications were received, they remained that way. It is recommended that future planning include a copy of detailed inventory for each spare parts box.

Ellsworth

Material was hauled direct from the ships to a supply dump at the base site. There it was unloaded from the sleds directly to the proper category marked by flags with letter markings. This system of material segregation worked out very satisfactorily. In future operations such as this, the inclusion of a piece of equipment with a swinging boom is highly recommended.

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Section VII

CONSTRUCTION METHODS

CAMP CONSTRUCTION

McMurdo

Transmitter Building

Deep Freeze II personnel did not participate in the selection of a location for the new transmitter building. Before they arrived, the site had been chosen and graded, and material for the building had been moved into place in preparation for placing of the counterpoise. The counterpoise was never extended beyond the building because the supply of wire was not sufficient to both finish the counterpoise and construct the antenna. Also, it would have to cross the access road to transmitters, and the ground in this area was too hard to bury the wire. The counterpoise consisted of #6 copperweld wire stretched both ways, making 1-foot squares, and bound together at the points of intersection by soft copper wire. The floor to the building was then laid.

Early in February 1957, the new transmitters were received from the ship and moved to the site and placed on the completed deck. The equipment for the antennae was also received, but no means were available to move it to the site selected for the antennae. The transmitters were uncrated and moved into place. The size of some of these transmitters was such that it was necessary to construct the building around them. There was 1/8-inch clearance between the top of the AN/FRT-15A and the roof trusses. A false roof was constructed of 4-foot by 8-foot plywood panels covered with tarpaulin to keep accumulated snow on the roof from melting and running down between the panels onto the transmitters. Roof leakage was never experienced in the transmitter building.

Transmitters installed were the AN/FRT-17, AN/AFT-15A, two AN/FRT-24's and a new TBM. The TAB transmitter was moved from the receiver building to the transmitter building. A 3/16-inch phospher-bronze wire was run around the inside of the building and all equipment was grounded to it. This wire was run to the power house and tied into the camp ground. In addition, it acted as supporting cable for the keying lines between the receiver building and the transmitter building.

New Garage and Public Works Shops Building

On 28 April 1957, the permanent garage and shops building was completely destroyed by fire. The next morning a new site was selected for a garage and Public Works shops building. Because of the extreme cold it was impossible to dig into the permafrost to set the foundation. Enough surface material was available to build the foundation up to the required grade. The shop building was erected on 8-inch by 8-inch timbers set on 4-foot centers. The building, 20 feet by 56 feet, was erected out of left over panels from the other buildings. Ninety percent of the panels were either for the floor or roof and had to be adapted for wall panels. The roof was reinforced by covering it with 1/2-inch plywood. On 4 May, the shop building was completed.

The garage was constructed on the same type of foundation as the shop building. To support D8 tractors, a heavy duty flooring of 4-inch by 12-inch timbers were used. Framing material was critical so Quonset ribs were used. To get the required elevation, one end of the rib was placed in a channel on the floor and the other end in a channel on top of the shops building which was 8 feet and 4 inches high. This gave an overall width of 18 feet 10 inches, a length of 56 feet, and a maximum height of 16 feet. The Quonset ribs were lined with 1/4-inch plywood and insulated with paper and some old cardboard drop cushions. The outside, also 1/4-inch plywood, was covered with canvas. A 16-foot by 20-foot extension was then added to the end of the shops building for a welding shop, and an 8-foot by 32-foot area was added to the side of the shops building for a parts room. Both the welding shop and the storage shed were wood-framed structures covered with plywood. All work on the structures had to be done under lights as the antarctic night had started.

Snow Melter Building

A connecting building was constructed between the galley and the galley storeroom to house a snow melter and storage tanks. It was a Quonset-type building 20 feet by 80 feet. The foundation was 6-inch by 8-inch timbers on 2-foot centers. The deck was 1-inch plywood. The ribs and outside covering were Quonset hut material. It was insulated with spun glass and lined with 1/4-inch plywood. Even though it was February and the temperature was above freezing a portable kerosene blow torch was needed to thaw out the ground to lay the foundation to grade. Once the foundation was complete the construction of the building was very rapid.

Little America

The site of Little America V is at Kainan Bay 3 miles in from the barrier on the Ross Sea Ice Shelf. It consists of fifteen buildings, two towers, and miscellaneous shops and covered storage areas. Construction commenced on 4 January 1956, and the last major construction of Deep Freeze I, prior to the winter night, was completed on 15 April 1956 with the addition to the recreation building. The base is constructed on a snow and ice surface reported to be 700 feet deep and is on a slight rise (150-foot elevation). In addition to the main group of buildings, there are two buildings and a 6000-foot by 300-foot runway known as Kiel Field located 1 mile to the east of the main station.

During Deep Freeze II, an experimental Army T-5 structure was completed. An access tunnel through the communications storage tunnel and extending to the new quarters building was constructed. No interior partitions were erected in the new buildings because the overflowing base population required their use as berthing areas. A covered area behind the three supply Jamesways was erected for use as storage for ships' stores. It consists of 2-inch framing covered with chicken wire and burlap; and overall dimensions are 16 feet by 53 feet. Head #17 was enlarged, and the addition was later set aside as a UT shop.

The sick bay was enlarged and remodeled to provide quarters for medical personnel, laboratory and office for the dentist, and rooms for the physiologist. The geomagnetic observatory and calibration buildings located on the west side of camp were moved to an area approximately 350 feet northeast of the camp because of the presence of buried ferrous material.

A heliport was prepared behind the food storage tunnel by leveling to facilitate transfer of personnel and material from camp to the ship. A garage addition 36 feet by 44 feet was constructed. The Balk Bridge was used for a deck, and panels were spliced to attain an 18-foot overhead. By welding an extension to the normal 20-foot Clements roof truss, a 36-foot span was accomplished. A spare parts room was constructed of a timber frame covered by chicken wire and burlap. The Polar repair wanigan was set alongside the garage and used as a heater and electrical repair shop.

A 350-foot tunnel from communications to the geomagnetic building was constructed and a 40-foot tunnel was constructed between the observatory and calibration building. Considerable shoring of tunnels and storage areas was necessary because of the very heavy snow load. A chapel was constructed of two Jamesways placed end to end. It had to be reinforced after six weeks as it had begun to collapse from a heavy snow accumulation.

Two LCM's were towed from the Barrier into camp and enclosed for beer storage. The structure consisted of a network of crossed cables covered with chicken wire and a parachute. A door was provided on the ramp end.

Re-zoning of the base electrical distribution system required two additional generators. To accommodate them, the electrical storeroom was remodeled by placing a new reinforced deck, strengthening the roof supports, and enclosing the space with Clements panels.

Byrd

On 23 December 1956, the heavy swing arrived at the site of Byrd Station, and the task of laying out the base began. Within two hours construction was started on the first building. With the arrival by aircraft of ten additional personnel, the shell of the building was completed by midnight and used for berthing space. The mess hall was begun the following day, and the shell was completed the third day. On 25 December, the floor was laid for the garage while the interiors were started on the other two buildings. The next day the generators were set in the garage and wall panels installed.

On the 27th, the galley was completed to the extent that hot meals could be served and the heavy swing departed for Little America. Three buildings were erected by the evening of the 28th and the fourth and final building was started. The head was erected on the 29th, and all efforts were then concentrated on the interior finishing schedule. The galley and powerhouse were 100 percent complete on the 31st. The station was commissioned on 1 January 1957. On 3 January 1957, all the buildings were completed; and the remainder of the time was consumed unloading aircraft, erecting antennae, laying out and conditioning a runway, etc. The structures at Byrd Station were constructed on a deep, perennial snow pack.

During Deep Freeze II, the wintering group erected five additional buildings. Each scientific group or discipline concentrated on their own building with the assistance of the general work force and the specialist rates, where applicable. Radical modifications were required on every structure assembled. Many deck trusses for the science building were bent out of shape, and empty fuel drums were counter sunk to afford a foundation for one end of the building. Several panels for this building and the Inflation Shelter required rebuilding. Iron nails and fastenings in the geomagnetic buildings required replacement with the necessary copper or bronze fittings. The Rawin tower legs were altered and used for the Aurora tower when the appropriate legs were not supplied, while the Rawin dome was mounted directly on the roof of the glaciology and meteorology building.

The recreation barracks building and the radio noise building arrived by the Tractor Train in November 1957. Many of the interior furnishings designated for the station also arrived at this time. During the winter night there was an absence of flooring, easy chairs, drapes, cleaning equipment, and paint in each building.

South Pole

During the construction of McMurdo, it was realized that there is little room for tent life during an all out construction effort in cold weather. A man can put in long arduous work days in extreme cold if he has a place to warm himself periodically and if he can relax after work and sleep in comfortable quarters. A warm, temporary building was desired that would be quickly erected, easily transported and air-dropped, and that would be comfortable and economical to heat at temperatures to -35 F. The Jamesway hut was determined to fulfill the criteria established. Three 16-foot by 24-foot huts were ordered for air transportation to the South Pole. Each unit cost a little over $2000, totaled 428 cubic feet and weighed 3322 pounds.

Furthermore, it was realized after a winter at NAF McMurdo that any covered heated storage that might be provided at the Pole Station, in addition to that planned, would be extremely beneficial to the wintering party. Therefore, the three Jamesway huts were planned as part of the permanent camp. In the field it was determined to make one hut 16 feet by 32 feet instead of 16 feet by 24 feet, and, using several additional 4-foot module sections provided by McMurdo, to make one long 16-foot by 56-foot building. The inherent flexibility of the Jamesway is appreciated more in conditions where field planning is so important. The Jamesway units were among the first material to be dropped at the Pole. Construction personnel erected the first hut on the day of arrival and slept in its warmth the first night. By the third day of work, the second hut had been erected. In three days the construction camp was basically complete with an expenditure of 140 manhours in erecting the two units. The larger hut was used for berthing enlisted personnel. The other unit housed the galley, mess, radio, aerology, office space, and quarters for the officer-in-charge and the civilian scientific leader.

Although the Aurora building was not to be erected until all other buildings were completed, a portion of it was erected earlier to provide work space, housing for the generators, and miscellaneous storage. This smaller version proved to be large enough. The 4kw Hercules generator and the 24 volt Homelite APU were installed. The heat from these generators kept the building warm, although the building was ventilated well to keep the generators from starving because of lack of air. Power lines were run to the adjacent Jamesways for lights, radios, and for the small air compressor used to pump up the field ranges. The remainder of the building was used for tool storage, repair space, and for storage of the Herman Nelson heater engine which was kept warm when not used. Sixty-four man hours were spent in erecting this shell. This is excessive, but it was caused by extensive carpentry work done on panels damaged during the air drop.

Construction camp operations revolved about aerial deliveries. Normally the aircraft operating out of McMurdo arrived at the South Pole shortly after noon. There were often three planes a day, the last plane arriving late in the evening. This caused the work schedule to start at noon and end after midnight when the last load of material dropped had been retrieved. A crew of from four to eight men worked on retrieving, depending on the type of material dropped, and the remainder worked on construction. All material was retrieved as it was dropped to prevent loss.

The permanent South Pole Station, as erected, is different in several ways than as shown by the drawings prepared by Deep Freeze I construction personnel. The Jamesways were incorporated as part of the permanent station. The floorspace of these two buildings totaled over 1400 square feet which can be heated if required. The one Jamesway was inserted between the garage and science building. In order to insert the Jamesway as planned, the permanent buildings had to be spread out on a grid east and west direction. This gave greater tunnel space as well as additional fire walls of drifted snow foi fire protection. The greater length of the actual camp achieved by spreading out the buildings was considered to be beneficial as less interference would result between the ionosphere program and the communications shack. In all cases where field changes were considered expedient, the senior scientist was consulted to assure that changes would not interfere with the scientific programs.

The priority of construction followed the planning priority, although some buildings were worked on simultaneously. The utilitymen and electrician followed closely as each shell was completed and installed heating, plumbing, and wiring. After all the utilities of the latrine were finished, the permanent galley utilities were installed. When the final construction personnel departed on 4 January 1957, all basic work was finished except to complete the ionosphere antennae, to erect barracks building, if received, to complete 100 odd feet of tunnels, and to complete special scientific buildings such as glaciology laboratory, etc. The interiors of many spaces, particularly the science building, were not finished off as the scientists would necessarily install their own equipment, and the allocation of spaces would depend to a large degree on the receipt of the barracks building.

The Deep Freeze II wintering group partitioned the mess hall and science building, and placed the last section of the Rawin dome. However, bolting together of the sections was only partially completed because of a shortage of bolts. Additional bolts, although ordered, were never received. While the dome remained partially bolted all winter, no defects or difficulties appeared. The small Jamesway was moved into the open slot between the science building and the garage. About mid-February, the Clements barracks building was air-dropped. The platform

containing the roof trusses was dragged 25 miles before the parachute finally collapsed. By the end of the month, the building had been erected between the garage and the mess hall. During erection, the barracks was enlarged to 20 feet by 56 feet by using spare and damaged panels left over from the initial construction. The senior scientist and the IGY group devoted half of their time during this period to general camp jobs. The cooperation received from the scientific group was nothing less than outstanding in all respects.

Since retrieving material after drops goes hand in hand with construction, it is interesting to note that only a little over 10 percent of the total manhours expended was in retrieving. When flying was the heaviest and material was spread over a great area, from eight to nine men were involved in retrieving.

Hallett

The construction of all buildings was accomplished with the exception of the Rawin Tower. The equipment to be housed on this tower was installed on the roof of building #2. Prior to installation, the roof panels were reinforced by covering them with a 20-foot by 20-foot pad of 3/4-inch plywood, and securing it to the roof with lag screws. A ladder was attached to the north side of building #2 to allow access to the dome. The remaining buildings were constructed and furnished as planned. All furnishings that were received were utilized. The decks of the mess hall, barracks, head, and science buildings were tiled. The decks of the recreation room and the hydrogen generator building were covered with linoleum. Decks were 20 degrees colder than the average temperature of the buildings. All building furnishings were considered adequate. The only shortages were some maintenance materials, such as siding and plywood.

Wilkes

A minimum of new construction is anticipated for this station during Deep Freeze III, and it can be accomplished with material available. Two Jamesways huts are being removed from the temporary camp area and erected in the main station area. Aerology will use one of them for storage purposes, the other will be for general supply storage. The interconnecting tunnels are being extended to reach the powerhouse, garage, science, recreation, and communication buildings. This will greatly expedite work during inclement weather.

Ellsworth

Temporary Camp

Eighteen 16-foot by 24-foot Jamesway huts were erected for a temporary camp to house the construction personnel. Erection was with a crew of twenty men. A portable 10kw generator was used to turnish power and lights to the temporary camp. Of the eighteen huts, two were placed end to end for a mess hall and galley; one used for communications, tool room, and field office; one for medical department; and the remaining fourteen to house the 126 personnel of MCB ONE, MCB (Special) Detachment BRAVO, and Air Development Squadron SIX.

Base Construction

The first material for construction of the permanent station arrived at the building site on 29 January 1957. Foundations for the Clements huts were begun at that time and worked simultaneously with the completion of the temporary camp. Construction continued during the next few days and was pushed to the maximum extent possible. On 10 February 1957, the Commander Task Group 43.7 announced that weather conditions and closing ice pack made it imperative that construction personnel be evacuated no later than 11 February 1957 or else winter over. When construction personnel were evacuated that date, the station was left 90 percent complete. To do this, half of the construction personnel worked thirty-six hours straight and the remainder twenty-four.

The project of transporting the material to the supply dump took twelve days. Six thousand eight hundred seventy-two measurement tons of material and equipment were handled. Priorities had been assigned to building materials with all components of a building having the same priority. These were then stored in the ship accordingly, but on the assumption that it would be possible to work any two holds on the ship simultaneously. In the very early stages of unloading the soft snow on the shelf progressively failed leaving an unloading area only sufficient to work two adjacent holds simultaneously. Some components of a building might be in a forward hatch and others in an aft hatch, which it had been intended to work simultaneously. The result was incomplete buildings at the site, especially boxes of interior finishing material. From the very beginning, construction proceeded at a fast rate which necessitated layout of work on the basis of material available instead of the desired priorities.

Foundations, sill and floor trusses for the mess hall, and two barracks were laid without incident or difficulty. One small innovation not called for on plans was required on the floor trusses, that of toenailing them to sills to prevent their shifting during placement of floor panels because of the unavailability of building material. The Clements panels clipped together satisfactorily for all buildings.

There were numerous errors in prefabrication, detailing, and provision of material for this project. These errors, which would be of minor importance on a normal job, consumed time that did not exist. All interior panels were about 1/2 inch too long for installation and had to be cut to length on the job. After the waste pit for the mess hall was dug, it was noted that the plans had the building rotated 180 degrees to the position that it should be to give access to the snow chute from the tunnel. The hatch for the snow chute in corner roof panel R3A was at the opposite end from that shown on the architectural drawing and did not match the position of snow melter. The panels were not reversible.* The oven was larger than called for on drawing. Its height was greater than height of wall vent opening. It was necessary to move the oven to center of the galley and cut the roof vent. Sinks furnished were larger than the opening in the metal counter top; requiring holes to be enlarged. The 6-foot long, 148-gallon, water storage tank turned out to be a 9-foot long, 300-gallon tank which did not fit into the space available. The tank stands for support of the storage tank were 8 feet high for use under an 8-foot ceiling. Three-eighth-inch I.D. copper tubing was furnished instead of 3/8-inch O.D. as called for. Fittings were for 3/8-inch O.D. No connectors were furnished to secure the Romex electric cable in the junction boxes. The 19-foot by 22-foot paulins that were to be furnished to cover tops of buildings turned out to be 18 feet by 20 feet and were not large enough to give any overlap over the sides of the buildings. No gravity louvers were furnished for the 8-inch exhaust fans. The architectural drawings for buildings (3) had an interior partition terminating at one end wall in the middle of an inward opening escape hatch.

Communication equipment was not unloaded until 9 February and completion of the communications building was delayed until that time. It was found that the framing over the garage doors was too weak to give adequate support to the garage doors. Sagging and improper functioning of the doors resulted. Sufficient time was not available to correct this deficiency. The 8-foot, 300-gallon water storage tank, to be mounted over the snow melter in the latrine, turned out to be 9 feet long. To install it, it was necessary to move rear bulkheads of closets forward requiring that new hatches be cut through the floor for the closets.

* A similar discrepancy was encountered in the installation of the snow melter in the latrine.

The decks throughout the camp, with the exception of the garage and generator buildings, were covered with rubber tile or linoleum. Both of these covering materials served their purpose very well. They were easy to install, keep clean, and were durable, in addition to being attractive. The linoleum was used in the mess hall and recreation building. The only difficulty experienced with it was its tendency to spread. A 2-inch strip had to be cut from all edges on a piece 20 feet by 25 feet placed in the mess hall. Different methods were used for laying the rubber tile. Either plywood or tar paper or both were laid beneath the tile. In other instances, the tile was placed directly on the wooden deck panels. Tiles were anchored to the deck either by waterproof cement, paste, or finishing nails. In all cases, the end result was about the same.

SEA ICE CONSTRUCTION

McMurdo

A great deal of time was spent in investigating the bay ice, in laying out the runway, and in constructing the runway on the ice. All investigations were made keeping in mind that logistic support of the runway was a prime consideration. This effectively limited the distance from McMurdo to the runway to a maximum of 5 miles, and preferably not more than 2 miles. This limitation was due primarily to the problem of transportation.

Commencing as soon as possible after construction of the base had reached a point of satisfactory progress and prior to darkness setting in, a systematic program of snow and ice observations were conducted with two objectives in mind. First, to find an area for an ice runway with ice of sufficient thickness to support a C-124 aircraft, and secondly, to find a site for a compacted-snow runway which would serve as an emergency runway for all aircraft and an operational runway for ski-equipped aircraft. Initially, both a compacted-snow runway and an ice runway were desired, if possible. Ideally the ice runway would be located in an area relatively free from surface snow, to minimize snow removal and maintenance problems. It would have sufficient thickness to require no pumping to increase the thickness. It would be fairly level. The compacted-snow site ideally would have ample snow cover and ice thickness to allow adequate compaction and safe bearing capacities. Both runways were desired as far south on the bay ice as possible to eliminate disruption of operations by ice movements and departure which are common early in the summer.

Since the area to be covered by the survey was too large for immediate ground survey, a helicopter was used for the initial investigations, locating favorable areas which were later visited by ground parties. During the offloading period (January-March 1956) the ice had gone out to a point about 4 miles north of McMurdo on a line running roughly northeast by east and southwest by west. The ice north of this line did not reform until early winter. Consequently, the initial investigations were limited to the old ice south of this line. There were several large tide cracks in the old ice about 4 miles west of camp that further limited the choice of runway location. Another very limiting factor was the location of Observation Hill in relation to the prevailing easterly winds. Observation Hill rises roughly 700 feet and any runway running in an east or west direction would have to be to the south of this hill or so far to the west of the hill as to make support extremely limited. This fact alone limited the choice of a runway site to an area lying to the south of Observation Hill within a radius of 1 to 5 miles. This worked out well with respect to known cracks and to the fact that we desired to keep the runway far to the south. However, it was found that this entire area initially had a snow cover varying from 30 to 40 inches. Using a hand anemometer, wind studies were made of the areas thought most likely to be chosen. The results showed that the winds over the ice varied considerably from those found at camp where topography had a great influence. During storms, the winds were found to swing from their normal easterly direction to the south, approximately perpendicular to the axis of any runway that might be laid out. This was a source of drift problem, as windrows immediately cause a serious drift accumulation. There were steady easterly winds but most of the storms carrying a great deal of snow were from the south. Easterly winds paralleled the long axis of the runways, depositing any drift at the ends where little damage was done. When the runway was actually laid out the sastrugi was used to determine the average wind direction.

Sites

At first, it was thought that several rough blue ice fields found about 5 miles to the south and southwest of camp toward the moraine fields might be suitable for a runway. However, the ice corings made of this area indicated a high degree of stratification, with weak spots which would be hazardous to aircraft landing gear. The ice was too thick for obtaining water for flooding, if desired. A snow compaction technique for the snow covered ice laying closer to McMurdo was next considered. This ice was thought to be several years old and had 2 to 3 feet of snow cover on it.

The new ice north of the Deep Freeze I offloading site was also considered. This site was level, and the ice was about 8 feet thick by the end of October. There was little snow cover. Wheeled aircraft could use it with no preparation in case of an emergency. The area was too far from camp to support and probability existed that it would go to sea in January or February 1957. This assumption was correct, as all this ice departed in early 1957. It was also marginal in thickness for continued C-124 operations.

South and southwest of camp at a 2-mile radius was a site with 30 to 40 inches of snow cover and ice 10 to 12 feet thick. This was the site finally chosen. The only solution deemed feasible to develop this site was removal of the snow cover from the old ice, pump water, if necessary, to level the ice, and cut adjacent parking aprons and taxiways. The construction officer was skeptical of the success of this operation because of the limited amount of equipment available and the problem of drifting snow in the resulting depression. Also, the limited repair facilities would preclude simultaneous full scale construction activity and the necessary overhaul of all equipment prior to commencing next season's activities. The runway being of first priority, the go-ahead was given and a 24-hour, 7-day week was established. The orders to the mechanics were to keep the runway equipment in operation.

The final runway was laid out after snow compaction tests were made, and that method abandoned. A strip 6000 feet by 225 feet was cleared which drifted partially full of snow during a series of storms in September. Flooding attempts made in this strip were not successful. This first strip was finally used as a snow trap for a second strip which was constructed to the leeward side of the first strip. Snow fences did not work although several were tried. A trench 225 feet wide with windrows on each side did catch the snow, leaving the runway to the lee side relatively free of drift. A large living wanigan was built for use at the runway site. The wanigan, equipped with two double bunks, a stove, and bench and table, was mounted on a toboggan sled.

The runway crew which started work 23 July, was composed of a maximum of 24 men, 12 on each shift. Support personnel, i.e., mechanics, steelworkers, machinists, etc., are not included. After pumping was discontinued on 27 July, the crew was partially reduced until 25 August when pumping was again started. The problem then included one of training as well as construction. Between 22 July and 15 October, a total of 8873 hours were expended directly on runway labor, not counting any base support (i.e., mechanics, steelworkers, etc.).

Points of Interest of Runway Construction on Sea Ice

1. During calm cold days (below -40 F), the visibility and, therefore, the effectiveness of the crew, might be limited by a type of fog caused by the exhausts of tractors and equipment working in the area. The exhaust rapidly "seeds" the air, and in the area or downwind of the area, dense clouds of fog develop.

2. The snow banks must be feathered out as far as possible to keep deflection of the ice to a minimum. Deflection causes cracks to form both along and parallel to the center line and also on the top, along and parallel to the edge underneath the windrows. The latter sometimes causes water to seep up under the windrows which is cause for constant worry on the part of the operators who are never too sure where the water comes from. The former presents a definite hazard to aircraft landing gear as the edges of the cracks break off with the passage of equipment over them, causing wide troughs to develop at the cracks. The deflection also hinders the proper flooding of the ice as water runs to the edges and forms deep puddles which do not freeze properly.

3. Communications are important. A field telephone between the base OOD and the runway was maintained. Often times, visibility would prevent a crew from returning to camp as scheduled. A quick call ascertained this fact and prevented unnecessary worry concerning the crew's welfare. If a crew departed camp in poor weather, a call upon arrival assured the OOD of the crew's arrival.

4. During periods of low visibility, runway crews not working at the runway were usually put to work in camp. There were always odd jobs to be done if the runway equipment in the garage did not require manpower beyond that available in the garage.

Maintenance of Sea Ice Runway

At McMurdo Sound the airstrips for both wheeled and ski-equipped aircraft are located on the sea ice. Since air operations constitute the ultimate mission of the base, this is of utmost importance. In addition, it was over the ice that cargo from ships moved to camp. It also provided the primary access way to the barrier and other portions of Ross Island. It was a potential avenue of approach to the continent. As such, it was of utmost importance to the operation and close watch was maintained on its actions. Surveys of the entire Sound were made weekly (oftener as the seasons advanced) to observe signs of ice movement and to measure thickness. Known tidal cracks and other fissures were examined, their width and depth measured. Estimates were made of the effect of the never ending pressure from the Ross Ice Shelf.

In October, the sea ice in McMurdo Sound extended to the vicinity of Cape Royds. At its outer extremities, its thickness was only about 2 feet. Twelve miles from camp at the point where the ice breaker unloaded her cargo in 1955-56, the ice was 6 feet thick. At the auxiliary airstrip, some 6 miles from camp, the ice was approximately 90 inches in thickness. At the main ice runway it varied from 10 to 13 feet thick. Snow cover varied from perhaps 20 feet at the edge of the barrier to practically none near Cape Barne. The old sea ice, except for Glacier Channel, which cut into Hut Point, extended out about 5 miles from camp. This ice varied from 10 to 15 feet in thickness.

The summer season brought its own variety of problems. Some were paradoxical and hard to understand. Long after the temperature of the air had risen to a melting point, the thickness of the ice continued to increase. There is a definite lag between change in air temperatures and sea water temperatures. This proved true, also, later in the season when the temperatures began to decline. But the warm air temperatures did bring melting on the surface, and pot holes formed. Operation on the ice during this period was a continuing nerve-racking experience as man, equipment, and time suffered.

Problem Areas

As the summer season opened, the surface of the ice runway was hard and fairly smooth. It had been obtained by moving an average of 3 feet of snow which covered the sea ice. On either side of the runway, the snow was windrowed in banks approximately 8 feet high. This constituted a tremendous weight which depressed the edges, creating a crown effect near the center of the runway. The depression was particularly noticeable on the south edge of the runway. This was due to the fact that snow was banked on this side from the taxiway as well as the runway. At the center of the runway, the ice was about 13 feet thick.

Flight operations commenced on the runway on 17 October 1956 with the arrival of the first VX-6 R5D. The other VX-6 aircraft arrived 18 October. The first Air Force C-124 arrived 21 October. Operations were heavy from that time until the middle of December when the strip was closed. Usually an average of three C-124's were present. In November very localized signs of deterioration appeared on the taxiways as a result of oil droppage. Any colored object on the ice tended to absorb heat and cause a melt spot. No deterioration at all was evident on the runway itself at this time. The main road from camp ended near the middle of the runway. To move supplies, equipment, and drop material to the planes on the taxiway, it was necessary to cross the runway with tractors and sleds. A roughness developed early at this point and constant dragging and planing was necessary.

During November, necessary maintenance of the strip was limited to daily dragging plus removal of finger drifts which appeared on the south sides of the strip and taxiway following snows. One, and sometimes two, D2's were kept busy at this. At this same time, the single operable D8 was busy around the clock extending and widening the taxiway to accommodate a fourth C-124. On 29 November, a C-124 landed short, damaging its landing gear, and skidded to a stop at the middle of the runway. A fire in the starboard engine was extinguished at this point. Extensive black streaks and marks were imbedded into the ice at this point. Realizing the heat absorption characteristics of these marks, every effort to remove or obliterate them was commenced the same day; but without success. The ice was simply too hard for the bulldozers to faze. Snow covering would not adhere to the hard, slick surface. In a few days, pools of water appeared at these points as temperatures were steadily rising to near the melting point. The water was pushed out with dozer blades and the holes filled with tightly compacted snow. This treatment was successful and several flights were made with no ill effects to the repaired area.

By the middle of December, however, average temperatures were above freezing. These same spots turned to water. The melt water pools rapidly spread over the middle of the runway, aided by the roughening and discoloration caused by traffic crossing the runway. On 19 December, the strip was closed to further operation. At this stage, several large pools of water were concentrated near the middle of the runway. Some were 1 foot in depth. Within three days, other pools had formed independently over the entire runway. So rapid was this process that it could almost be seen. Maintenance efforts ceased during this period and all traffic was denied access to the runway. About 30 December, temperatures dropped below freezing and winds picked up. For a week the temperature averaged about 25 F. On orders from the Task Force Commander, ship off-loading operations were halted and all available manpower and equipment were devoted to airfield maintenance efforts. Attempts to obtain a usable runway were twofold:

1. Repairs to the existing surface

2. Widening of the runway to obtain undamaged ice

The problem faced in the first of these attempts was the elimination of the melt water pools and their replacement with a smooth, solid surface. The cool weather quickly froze the surface of the pools. However, freezing did not penetrate much more than 3 inches over pools about 3 feet deep. In addition, air pockets were left between the ice and the water in some cases. Some means of speeding the freezing process was obviously mandatory.

Consideration was given to draining the pools and refilling the remaining holes. However, with the pools spread over the entire 6000-foot by 250-foot area, this was deemed impractical. The following process was decided upon as most practical: the D8 bulldozers were run over the runway, breaking up the newly formed ice in the pools. It was found that exposing the water to the air in this manner both speeded the freezing and eliminated the air pockets between the ice and water. Ice and snow were pushed into the holes and tightly compacted. A 4-inch cut with snow mixers was made over the entire runway. This removed surface irregularities and provided fill material for the holes. It also provided a bright white surface which definitely retarded melting. A crew of men followed the snow mixer, filling and leveling small holes. Snow planers and rollers worked over the entire surface.

It is believed that this process would definitely have cured the surface had the weather remained favorable — below freezing. (In fact, it is understood that virtually this same process was utilized when repairs were finally successful after Detachment One departed.) However, on 5 January, warm weather returned, and the melt water pools reformed. From then until Detachment One departed, maintenance efforts were limited to daily inspection and breaking of ice forming over pools.

The second effort, widening of the runway, was made with four D8's, working 24 hours per day. Snow on the north edge of the runway was pushed back a distance of 125 feet. With the exception of a point near the middle of the runway, the ice exposed was relatively smooth. However, the weight of the snow caused cracks of 2 or 3 inches in width to appear and caused the entire widened area to slope markedly. Thus, this surface was judged not to be usable without additional processing. Therefore, when Detachment One departed McMurdo Sound 20 January, the runway was still not usable. About this same time, Detachment Bravo commenced maintenance efforts which, aided by a SIPRE representative and cold weather, were eventually successful.

Restoration of Ice Runway

Black marks left by vehicular traffic crossing the runway became the focal point for excessive melting when the warm season approached. Hydraulic fluid oil, dropped by a taxiing and landing aircraft caused rapid deterioration under the warm sun. By the early part of December, it was apparent that operations could not continue on the ice runway. This, coupled with the exhaustion of the aviation gasoline supply, was the cause of the C-124's returning to New Zealand.

While short cold snaps would return and were the occasion for turning all hands and all equipment to on the runway, they were always short-lived; and it was not until the end of January that cold weather finally came to stay. It was found that a far superior system than flooding is that of smoothing the surface of the ice by utilizing several snow mixers. A SIPRE representative came to McMurdo in late January to assist in the reconditioning. It is greatly regretted that a member of SIPRE was not permitted to winter in or at least to arrive in October that his experience and skills might have been utilized. It is here noted that none of the wintering officer personnel, including the civil engineering officer, had ever had previous experience with either snow compaction or ice runway construction or operation; and it is respectfully submitted that the successful construction of the runway was not due as much to talent in this direction as it was to grim determination and persistence.

Due to the vital importance of the ice runway, it is necessary to assign a minimum of two heavy equipment drivers to duty exclusively at the runway during the period of wheeled aircraft operations. Their duties would include daily inspections of the entire runway surface and twice weekly corings at 500-foot intervals along the side of the runway to check the ice deterioration from beneath. Between takeoffs and landings, and coordinated with the control tower, appropriate passes with the snow mixer should be made to level off any rough spots developing. These personnel should be directly responsible to the GCA officer who, in effect, would control all the operations at both the snow and ice runway sites.

Sea Ice Base Techniques

Basically, the use of flooding techniques was for the purpose of leveling ice rather than building it up to sufficient thickness. The old sea ice, adjacent to McMurdo, within logistic support distance, varied from 10 to 15 feet in thickness, but it was covered with an average layer of snow 36 inches thick. The new sea ice to the north was 78 to 90 inches thick by 15 October 1956 and had a smooth surface. However, a runway could not be supported logistically on this new ice, and, in all probability, it would go to sea before air operations were completed. Therefore, on 23 July 1956, after all other methods were evaluated and deemed impractical, an all-out effort was commenced to strip the snow from an area 225 feet by 6000 feet and to flood any rough areas with a minimum amount of sea water to level the surface.

The roughness of the sea ice in the area chosen was much greater than anticipated. Towards the eastern end, where pressure waves started to form off to Cape Armitage, depressions as great as 2-1/2 feet were found. In addition, the construction technique of pushing the snow into windrows along the length of the

runway caused difficulties. A crown developed along the length of the runway as much as 3 feet higher than the elevation of the sides. The crown caused water to flow to the sides and, as the ice flowed in a plastic manner, caused breaks in transverse dikes of snow built to retain water in many specific areas. Water would be retained in some depressions, but the majority would run off. The rough ice to the east caused the snow removal crews to stop moving eastward and to work west where the ice was smoother.

By 30 July, over 1000 feet of runway, 225 feet wide, had been cleared. However, the windrows on each side were much too high and were not spread out far enough. The excessive weight caused great deflection and cracking. The work had to be redone as much as possible, pushing the windrows back as far as possible.

Between 23 and 27 July, extensive pumping operations were endeavored. Equipment had been tested and men trained the preceding months. During testing, both hoses used for flooding were found, after 8-1/2 hours of operation, to be severely restricted in their interior openings by the continued formation of ice. The large 6-inch hose had its interior cut to 2-1/2 inches, the other 3-1/2 inches being a wall of sea ice; the smaller hose was similarly affected. Personnel working on this detail were drenched frequently from the splatter of water and occasionally from the nozzle getting away from the individual having hold of it. Working in the darkness (the flood lights on the wanigans had limited range), trouble with the leaking dikes and the resulting pockets of weakness, and failure of the ice auger resulted in postponing the flooding operations until the middle of August when sufficient daylight returned to allow positive control. Because of brine concentration, no more than 2 inches of sea water can be pumped at any one time. By mid-August the initial 225-foot by 6000-foot strip had been cleared out. The pumping crews used two wanigans and started on the eastern end of the strip, working their way west. One wanigan could pump in a 225-foot by 300-foot area at any one time. The runway was divided into 20 sections. In spite of all controls, the crown, leaking dikes, and large depressions caused accumulations of more than 2 inches of water.

By 9 September, as the auger continued to break down daily, less than 1000 feet of runway had been flooded; and pockets of brine were still found. With the auger failures, one pumping crew was fortunate if it could drill one 15-inch suction hole through 12 feet of ice in a 24-hour period. Several small storms hit early in September, causing a great deal of drifting in newly poured water. This also caused removal and reflooding problems. In spite of the efforts of the crews, by the middle of September, a satisfactory flooding technique had not been developed. After the men learned a few precautionary measures, they were able to keep the water flowing continuously. However, on 17-18 September, a blizzard hit the runway and filled it with drifting snow. At this time, it was discovered that the large cleared aircraft

parking area to the lee side of the runway had not drifted in, all of the snow having been caught in the runway itself. The decision was made to abandon the first strip, relegating it to the job of acting as a snow fence for the new strip which was to be built by extending the parking area.

Although rough, the new strip was not rough enough to prevent air operations. Many ridges were ground down by the tracks of the D8. The pumping operation was abandoned as the new strip consumed the efforts of all hands for snow removal in order to complete it by the 15th of October deadline.

In essence, a pumping technique for this particular situation was not worked out. The sprayed dikes worked well as long as they did not split from the deflection caused by the windrows. The water could be pumped continuously as the wanigans were efficient and the crews knew how to operate them. Control of water depth was difficult because of the roughness of the ice surface and the crown. The failure of the ice auger, which is paramount to successful and rapid operations, was not only discouraging, but is thought to be the primary factor for the lack of success in this operation. As time ran out, all efforts had to be directed at other projects throughout the air facility.

Recognizing now the problem of excessive melting due to warm temperatures around Ross Island in the summer months, it is known that sea water should not be applied to any runway in this area. The melting which would ensue in the salt water ice would exceed by far that experienced in the old sea ice, which, in itself was bad enough to halt air operations for over a month.

Recommendations

1. That future planning assume that the runway at McMurdo Sound will not be operable between 15 December and 1 February.

2. That all traffic, except maintenance vehicles, be prohibited from crossing the runway.

3. That the possibility of an insulating cover of some variety be investigated.

4. That snow banks are kept as low and wide as possible for safety of aircraft operations and to reduce drifting and deflections of ice.

Construction and Maintenance of Ice Runways — Deep Freeze II and III

In March 1957, the ice runway was cleared of all installations and debris. All runway markers, except the P2V tail marking the 1-mile point from touchdown, were secured. The piles of snow on the sides and ends of the runway were feathered down to try to eliminate abnormal snow drifting during the winter months.

15 August was set as the date for work to begin on the runway for Operation Deep Freeze III. The old runway was 150 feet by 5000 feet and it was planned to enlarge this area to 200 feet by 7000 feet. The ice thickness of the area averaged 15 feet. The snow that accumulated from March to August varied from 1 foot to 5 feet. Two pieces of equipment were available to start construction, one D8 and one snow plow. The dozer pushed the snow in windrows, and the plow with its chutes elevated tossed the snow toward the sides. The plow was set at a speed of one-half mile per hour which proved very effective in clearing a 12-foot strip of 3-1/2 to 7 feet of snow. Working a 24-hour day the clearing was practically accomplished when a heavy snow storm stopped operations. Because of the heavy snowfall and adverse winds, work was suspended.

Clearing of the ice runway was again started and progressed rapidly with the equipment operating an average of 20 hours per day. The surface condition of the ice was generally excellent with the exception of four ridges that transversed the width of the strip. The highest ridge was approximately 30 inches above the grade of the smooth ice. Three-inch cores were taken down to the runway elevation and two sticks of dynamite were placed in each hole and detonated. The results were excellent, and the ridges were completely cut down to grade. A D8 then bulldozed the area, and all contamination caused by the dynamite was removed from the surface. The runway was then completely pulverized with the snow mixer blades set to penetrate 1-1/2 inches. The snow mixer worked perfectly, and the finished surface conditions appeared ideal for wheeled vehicles.

The D2 was then used to tow the planer to eliminate any rolls or small ridges that could effect the performance of wheeled aircraft. The planer is dependable and the final surface condition depends upon the smoothness and texture of the ice. One inch to two inch depth of pulverizing makes ice chips which are well graded and when planed give a white rough surface to the runway. If the temperature is below freezing, the chips will solidify into a rough textured surface that gives excellent traction for wheeled aircraft. The runway surface remained in excellent condition throughout October and November. Reports from pilots landing or departing on conditions of runway were received by the GCA operator. If any adverse conditions were reported, immediate corrective action was taken.

The basic layout of the runway heading (252 F grid) was considered ideal for McMurdo. Several times a cross wind from the south made landings rather hazardous. The winds from this direction were not of long duration. However, this condition could be remedied by making a short runway at right angles to the 280 F grid to insure a plane could make an emergency landing during adverse wind conditions. The GCA should be so located to adopt its use for the emergency strip and the main runway. The U. S. Air Force runway criteria was not available at the time of construction but the international orange paint and pine trees were quickly procured from Christchurch and all criteria met.

SNOW COMPACTION

McMurdo

Several experiments were tried with snow compaction during the winter night between 1 June and 23 July 1956 but the method was not pursued for the following reasons:

1. The basic aircraft for which a runway had to be built was the C-124. This aircraft is very heavy and the requirements for the runway were correspondingly difficult to meet. The required minimum Ramm hardness numbers according to the Snow, Ice, Permafrost Research Establishment (SIPRE) for a C-124 wheeled aircraft are as follows:

Depth of Snow in CM	Ramm Number (R)
0-10	100
10-15	290
15-20	288
20-25	280
25-30	270
30-35	264
35-40	252
40-45	236
45-50	230
50-55	224
55-60	216
60-65	212
65-70	200

Although hardness was obtained up to 300R, the test strips did not prove uniform in nature and sufficient hardness at depths was not obtained. Paragraph two discusses in detail the results of these tests.

2. The 225-foot by 6000-foot runway had to be operational by 15 October 1956 and remain operational until the completion of the Pole Station and Byrd Station, estimated to be March 1957. This meant that construction would have to take place during the winter night, definitely not the optimum construction period.

3. Equipment and manpower limitations would not allow construction in the time allowed. Only one snow mixer was available, and equipment availability was low.

4. The ability to maintain a strip once constructed for the long warm summer months was questionable (later proved impossible). Over 500 operational flights were subsequently conducted from the McMurdo airstrip. It is now known that the hardness could not have been retained for the entire operation, as the temperature frequently rose above +32 F.

5. The importance of the runway could not permit taking a chance with something that might not work. Pole Station was undoubtedly the most important station from the standpoint of national interest and public relations, and, as such, a dependable runway had to be built at any cost.

6. Maintenance of any strip would be a continual problem due to drifting snow. The prevailing fair weather winds are easterly. Thus, a runway would have to run east and west. The storm winds, however, are southerly, causing excessive drifting the entire length of the runway and not just at the ends. Snow fences of several varieties were tried with no success; the blizzards of McMurdo Sound run very deep and quickly obliterate snow fences.

7. Several experiments were made using salt water to assist compaction, but without success, due to brine concentration.

Snow-Compaction Results

Three test strips were laid out on the snow cover approximately 1-1/2 miles from camp in 32 inches of snow. The average Ramm hardness number for the unprocessed snow was 132R. However, the snow was highly stratified as was all of the snow in this area. "It was found that low temperatures and fine dry snow are not conducive to compaction."[15] An accepted processing procedure was used as follows:

One snow mixer pass
Two rollers passes
Three snow mixer passes
Five rollers passes

As a result of this process, the test strip compacted 24 percent of its original thickness. At the end of one hour, hardness averaged 72; at the end of twenty-four hours, 175; at the end of forty-eight hours, 210; and at the end of seventy-two hours, 232. Although this was still too low for our purposes, the values of multiple processing and age hardening were evident. Since it was evident that further processing was beyond our capabilities, the compaction program was abandoned for a more positive solution. It is believed that under optimum conditions, with adequate time, manpower, and equipment, a suitable strip could be made to land a C-124; this strip could not be made satisfactory for continued operations since the average summer temperature is above +10 F to +15 F. From 15 December to 15 January, temperatures averaged close to +32 F. It was found that additional processing did increase hardness (an R of 375 was obtained in a limited area), and uniformity throughout depth was improved. "Initial results indicate that a combination of compaction and controlled flooding produces a dense hard mat."[15]

"After initial processing, average hardness was 230R; after final processing, 375R, with density averages .57 gm/cm^3. Thickness of snow layer decreased approximately 25 percent with the initial processing. The test strip is 28 inches thick and displays acceptable uniformity. Although the criteria values vary, I believe it indicates the compaction process produces hardness sufficient for ski-equipped and wheeled aircraft of R4D size. The snow is extremely dry and fine. Manhour studies and equipment evaluation, however, show that a compacted runway built by the process indicated above is not feasible at the present time. Manpower and equipment are insufficient and the hardness index is believed too low to support all aircraft."[17]

"Your letter NT4-9/OperDF, 200 BI/J4 of 17 October 1955 discusses the application of water as a hardening agent on the compacted-snow runway. My 161025Z (Reference 17) has results of normal compaction tests. McMurdo sea ice with heavy snow cover offers unusual opportunity to test application of sea water. Construction Officer believes dense, uniform, hard mat could be built using the spray rig built into the snow mixer to increase penetration and distribution of water. Use of rig with adjacent pumping wanigan (1000-gpm pump) and 300 feet of 2-1/2-inch hose would deliver 75 gallons per 100-square-foot area per pass of the snow mixer. Note that this is twenty-five times more water than used at any previous test. Runway sufficient to carry aircraft similar to the C-119 or C-124 is the objective. The method of construction, if perfected, might provide an answer to

future wheeled aircraft operations in the McMurdo area where heavy deflection and heavy drifting present a continuing problem of removal and maintenance. Emphasis on an acceptable ice runway by October for C-124's, as indicated in my 250515Z, prohibits further testing at present. Believe importance merits testing program during Deep Freeze II."[23]

"Representative centigrade air and snow temperature data for runway: air temperature minus 42 degrees (-44 F), and surface snow minus 38 (-36 F); minus 40 cm, minus 27 degrees (-17 F); minus 80 cm (ice surface), minus 22 degrees (-8 F). Density unprocessed snow varies between .38 and .45 grams per cc. Great air temperature differential experienced at runway. Minus 60 degrees (-76 F) to 0 degrees (32 F) during construction period."[25]

Construction of Ski Runway

Adjacent and parallel to the ice runway, a ski runway was constructed for use of the P2V, R4D, and Otters during Deep Freeze II. This freed the ice runway for sole use of the C-124 aircraft during peak operations.

Very little work was required to convert the existing snow cover to a very satisfactory surface for ski-equipped aircraft. After the initial compaction by roller and dragging, the best combination found was simply maintaining the strip by continued planing with occasional rolling to keep the surface level, hard, and smooth. No particular troubles with the skiway were experienced even in the warmest weather. Formation of seal holes at the east end of this runway caused it to be closed, except for emergencies, on 1 February 1957.

In selecting a location for the Deep Freeze III ski runway, the following conditions were considered:

1. The prevailing wind in the area by past experience has proven to be a heading of 280 degrees (grid). During October, however, three storms blew from the south which made landings in cross winds very hazardous. It is the exception to have a wind from this direction, and it is usually of short duration.

2. The ice thickness averaged 10 feet and the snow was 3 feet thick.

3. It was essential to connect the ice runway with the skiway, as the permanent GCA installation made it imperative for all planes to land on the ice runway in bad weather.

4. In order to expedite maintenance to ski planes, and eliminate transporting of personnel long distances, and for a sheltered parking area for the planes, a location was selected under the lee of Observation Hill adjacent to the VX-6 hangar. It proved to be an ideal location.

An area 120 feet wide and 7000 feet long was selected and marked with 12-inch-square Daglo-painted panels every 200 feet on the sides. Touchdown was marked with three 2-foot by 8-foot cloth panels. One-half mile from touchdown on the approach end, a line of eight barrels at right angles to center line of strip were placed. A single line of barrels were placed on the center line at 200-foot intervals. The pilots that used the skiway were all favorably impressed with the layout.

To construct a ski runway the only two essential pieces of equipment needed are D8's and snow planes. In preparing the snow surface, the D8 blade is lowered to bite into the sastrugi approximately 3 inches below the surface. At the same time, the D8 tows the plane. The complete surface of the runway is treated in this manner. After the crust has been broken up by the blade of the dozer, the blade is raised and the D8 or D4 tows the plane to rework the surface until it is level and smooth. It takes three passes of the plane over the overall skiway to produce the desired surface. The towing speed of the D8 in third gear is approximately three and one-half miles an hour, so a 36-hour period is sufficient time to complete a skiway 120 feet by 7000 feet.

After the surface is prepared, the snow is granular and sluggish; but a few hours of cold wind will completely change the texture of the top snow to a glazed hard surface. Barring snow storms or drifting snow the surface requires very little maintenance. However, if a surface washboard condition does appear, or if the pilots find a rough spot, immediate planing should eliminate such conditions. If possible, pilots should not have to reverse props to retard speed. Reversing props causes the surface snow to be distributed and snow ridges will be formed which grow larger when wind conditions cause drifting.

During the period from 1 December to mid-February, when the snow and ice begin to deteriorate, the skiway should be checked with a 3/4-inch SIPRE auger in order to check the safety conditions of the ice. When deterioration is rapid it will be necessary to take 3-inch cores in order to get positive information on ice conditions.

Recommendations

1. Eliminate all vehicle traffic from ski runways.

2. Clean all foreign material from surface as quickly as possible.

3. Plane runway only when weather is below freezing.

4. There is no substitute for a snow plane — don't use drags of any kind as they cause a washboard surface condition that is hazardous to aircraft.

Little America

The snow compaction attempted at Little America consisted of preparing an airstrip 6000 feet by 300 feet for ski-equipped aircraft. This was accomplished by having D8 tractors pass over the area until it was considered hard enough to accept ski-equipped R4D aircraft. In addition, a test was made to ascertain the possibilities of compacting snow over an area 500 feet in length by 300 feet in width. With the snow mixer cutting to a depth of 12 inches, two complete passes were made over the area after it had been leveled using a D8 caterpillar tractor. It was found that the snow, after use of the snow mixer, would disintegrate into very small particles resembling grains of sugar. It is considered that due to the dry powdery condition of the snow, the snow mixer was not satisfactory for compaction purposes. "Rolling was tried in early February 1956. The rollers compacted the snow approximately 6 inches which, after about 30 minutes, produced a fairly hard surface temporarily."[8]

Byrd

Initially, the ski runway was laid prior to determination of prevailing winds. The runway, 6000 feet long and 200 feet wide, ran NNW to SSE, grid bearing 015 degrees (108 degrees true), which proved to be crosswind, but was used for the remainder of Deep Freeze II. It was marked on both sides at 100 foot intervals by Khaki Parachute flags on 4-foot bamboo sticks. Nine empty fuel drums were placed approximately 300 yards from the SSE end of the runway for a visual and radar line-up point. The only runway maintenance consisted of driving a D8 over the runway to break sastrugi crusts. This was done prior to each landing.

A new runway was laid 16 September 1957. This new skiway was approximately the same size, had red flag markers, and was laid into the prevailing winds of NNE, grid bearing 285 degrees (018 degrees true). Fuel drums for visual and radar line-up were in two parallel rows extending out from the southern end. Maintenance and flight preparation were the same as before.

Beardmore

The Sno-Kitten was utilized to pull a drag and smooth out an area suitable for ski-equipped aircraft to land.

South Pole

The characteristics of the snow observed at the South Pole are that the surface snow is extremely dry and of approximately 0.30 gms/cc density. It is composed of very fine granules less than 2mm in diameter. It is very soft, the undisturbed snow having a Ramm Hardness number of between 10 and 30R for the top 3 feet. Tests were made in Dr. Siple's test hole at -18 F, which showed a maximum natural hardness of about 180R at -18 feet. On the dragged airstrips which had been "worked" by tractor and drag, the hardness of the top 30 or 40 centimeters ranged between 30R and 45R. The snow is of a uniform nature with little stratification. It is also extremely cold. Dr. Siple reported a probably isotherm of between -57 F and -62 F at -15 feet. The warmer temperature, taken in a Rammsonde Rod hole, might have been caused by friction heat from driving the hole. The -62 F temperature is probably more correct. The snow becomes more dense with depth, and the snow becomes harder at depths as indicated by the Ramm Number Index. However, a great deal of hardness is believed due to the extreme cold and not due to density or compaction. This clearly would indicate that the relationship of hardness and density is not linear.

The two runways, 10,000 feet and 5000 feet long, were maintained through mid-February 1957 by dragging with a drop platform and a pipe drag of 4-inch pipe pulled by the D2 tractor. These knocked down the sastrugi and leveled the strips. The strips became hard, compared to surrounding snow, due to working the snow and compaction by the tractors. The hardness of the top 30 or 40 centimeters ranged between 30R and 45R. On 4 December 1956, the airstrip was dragged with parachutes to smooth it. It was hoped that this would keep the aircraft skis from sticking so much, thereby saving on JATO.

In October 1957, the 10,000-foot strip was reworked; the shorter one was abandoned as it was not required. As the D2 was then inoperative, dragging had to be done with weasel. The sastrugi which had formed during the winter was up to about 18 inches high and was quite hard. The pipe drag was inadequate; but a drag made from the frame of a drop platform and two 6-inch by 8-inch foundation timbers proved adequate. Though the strip was still somewhat rough, it was safe for use. After the D2 was repaired, the platform drag was used to further smooth the runway.

The major problem was that while the sastrugi were very hard, the hollows in between were partially filled with softer, wind-blown snow. Consequently, the drags, after knocking the tops off the sastrugi, tended to scoop the snow out of the hollows and actually amplify the broad undulations in the surface. Blading was attempted, but proved to do much more harm than good. The D2 cannot level the snow by blading, no matter how good the operator. The runway was later lengthened 2000 feet by making two passes with a heavy and light drag in tandem. At this time (mid-November), the sastrugi were considerably less hard, making leveling much easier.

Recommendations

1. Provide a snow plane for use in leveling the ski runway. All drags used were basically unsatisfactory as the surface could be only partially leveled.

2. Investigate the possibility of constructing a compacted-snow runway. It is believed that such a runway could be built, and the advantages which it would provide are obvious. The mere mixing of relatively warm surface snow (in December and January) with the colder snow beneath the surface resulted in an extremely hard mixture after it had "set" for about a day.

Ellsworth

The snow cover of the Filchner Ice Shelf was very soft and powdery as is common in the antarctic. This snow does not easily compact. Instead as vehicles pass over it, it churns up to a very loose and unconsolidated condition which gives very poor support. The initial snow cover had varying hard and soft spots. This, coupled with the short track length of the D4's, gave an extremely rough washboard trail in the early stages. Efforts were made to use D4 snow blades to smooth out the trail. Because of the short track length of the D4's little progress was made. As soon as the two D8's were unloaded, the blades of these were used for smoothing of the trail. With an occasional additional pass of the tractors without sleds, the trail was maintained in excellent shape. At the completion of ship unloading, the trail had been compacted to a level of 4 feet below the undisturbed snow and was beginning to show signs of stabilization and compaction.

BLASTING

McMurdo

Explosives in the antartic can be used for numerous purposes and are essential for many projects, such as breaking down sides of crevasses, breaking the face of the barrier, blasting the utility poles, decomposing large volcanic rock, and

eliminating pressure ridges in runways. During the summer season when temperatures were between 0 F and 38 F no difficulties were encountered. However, when the temperature is below 0 F the following deficiencies occur:

1. Electric caps detonate slowly and seem to have a delay action.

2. The blasting machine plunger was difficult to operate and had to be kept in a warm place just prior to use.

3. Friction tape lost all its adhesive qualities.

4. Primacord and safety fuse became very brittle causing frequent misfires. The cause was due to the brittleness of the outer casing. When the casing was bent the powder chain would break. If kept warm and pliable, misfires were eliminated.

5. The galvanometer dry cell batteries would freeze and cease to function at -10 F. This can be eliminated by keeping the instrument warm.

6. When the temperature is below -10 F, firing wire for electric firing was not successful due to the rubber covering becoming so brittle the insulation cracked and flaked off.

Blasting in this area presents several problems, the largest of which was providing deep drill holes in which to set charges. An additional problem was that of damage to radio equipment as a result of the concussion from the blast. Due to compressor failures, the jack hammer or rotory air drill could not be used. The jack hammer was not too effective but could be used with patience. Consequently, charges could not be set deep and were relatively ineffective. For setting antenna poles and anchors, 40-pound shaped charges were fairly effective. Two 40-pound charges produced a hole in the permafrost approximately 1 foot in diameter and 5 feet deep. This was deep enough for the feet of the guyed poles. A rotary drill (Powervane) combined with a soft coal auger, using carbide bits, was effective in drilling holes 1-1/2 inches in diameter up to 6 feet deep as long as the compressor was operative. Such holes were used for anchor rods for tying down buildings and for guys to poles. The steam jenny ordered for Deep Freeze II should prove useful to assist in penetrating the permafrost.

In the erection of telephone-type poles for Deep Freeze II communications and powerlines, it was found best to freeze them into a hole about 5 feet deep because it eliminated the need for guy wires. Trying to blast such a hole was a waste of time. One man could make three or four holes a day by building a small fire over each prospective hole which melted a few inches of permafrost. He would proceed from

one fire to the next and in turn dig out the loosened earth and reset the fire in the hole. In the erection of light poles which required guy wires, a shallow hole for footing was all that was necessary as the guy wires attached to dead men. The dead men were sunk relatively easily through permafrost and ice to a depth of 3 to 6 feet by using an air drill. Extreme caution must be used to not freeze the drill in the hole; blow air into the hole and lift the drill out frequently. A long steel rod with an eye for the wire can be frozen permanently into the hole.

The following explosives are recommended for antarctic use:

40-pound shaped charges
15-pound shaped charges
Composition C-3
20-percent nitro dynamite
Nitromord (Red Cross) Dupont
Primacord
Safety fuse
No. 6 caps for seismologists (16-foot leads)
No. 8 engineering caps (16-foot leads)
1, 2, and 3 second-delay caps (16-foot leads)
MI fuse lighter

Section VIII

STRUCTURES

GENERAL COMMENTS

"Winds reached prolonged peaks of 90 mph at McMurdo. The buildings held up well. Quonsets were tied down at the ends and center with 3/8-inch cable, and all corrugated metal was screwed down. All panel buildings built directly upon earth withstood winds in an excellent manner. These buildings were also tied down with 3/8-inch cable. Two buildings, built upon trusses, showed considerable vibration during high winds."[6]

"The Chapel at McMurdo was tied down after being blown off of its foundation on two separate occasions."[6]

Recommendations suggested by the South Pole Deep Freeze II group, applicable to all, were:

1. Some sort of gasket should be made to be fitted around the stovepipes at their entrance into the roof. The heat of the pipes tends to melt snow at this juncture and the melt water drips into the interior of the building.

2. The metal door handles deserve some type of cloth covering on the outside. Although the acclimatized hand is generally too dry to stick to bare metal, the danger persists.

3. The situation within each building when there is power failure must be carefully studied. Not only is there loss of light but also loss of heat where Jet heaters, generators, or galley stove are the sole heaters. (The Preways operate without electricity.) During Deep Freeze II, power failures were never of sufficient duration to cool the buildings appreciably, but the Herman-Nelson was kept to be used in vital areas in event of emergency. Coleman lanterns, kerosene lanterns, and candles were always available in addition to flashlights during power failures.

FOUNDATIONS

McMurdo

Surface material of the Hut Point area is a nonhomogeneous basalt ranging from large boulders to particles that remain in suspension more than 24 hours. The site is gently rolling terrain, volcanic in origin. Some hills are thought to be terminal moraines, indicating glacial action in the past. Permafrost was found from 12 to 25 inches below the surface. Drainage of some areas was poor, causing melt water to pool in these areas. If the topography would allow drainage, the soil would drain rapidly. By late January and early February 1956 the permafrost level had risen to approximately 6 inches below the surface. Consequently, fill was difficult to find and excavation was nearly impossible. A dozer can take a couple of inches off an area every day during December through February, so hills can be leveled and fill obtained.

The methods used in controlling settlement and heaving of buildings caused by the melting and refreezing of the permafrost beneath the buildings consisted of insulation, ventilation, and drainage control. As indicated above, little fill was available on the site. In addition, little equipment could be spared from off-loading operations to scrape up the cover of adjacent areas and to haul the fill to the site. Dozers could have scraped some up, but the largest bucket available was about 1/2 yard. However, very little material was taken from a site. In most cases, material was added to level an area. Excavation was resorted to only when absolutely necessary. Foundations during Deep Freeze II were prepared by skimming the pressure points to a level position and freezing it in place with a little water.

The foundations were kept low so that the deck of the building was only a few inches above ground level, which enabled the volcanic formation to be easily banked and thereby seal the deck from strong winds beneath the building. The foundation sills and stringers were placed to allow circulation of air underneath the building. In the summer months air could circulate, preventing the heat from the building from melting the permafrost. In the winter, snow would drift around the buildings to cut off the very cold air. The outside air temperatures are cold enough to prevent thawing without opening the foundation to the elements. Boards were used to close off the air space where drift would not naturally form.

The above combination proved to be satisfactory as no settlement or heaving was noted during the one-year period observed. One particular caution that must be observed is to assure that little snow is mixed with fill. During the construction of several temporary buildings late in February and March fill containing a high percentage of snow was used as no other was available. During the summer months the snow melted and the buildings settled. The buildings then had to be shimmed up to bring them back to level.

Remarkably few foundation problems occurred during the summer of 1956-57. The wintering group had built well, despite the adverse conditions. Only in two or three instances was sagging sufficient to require shimming. Probably the worst factor was drainage. When the spring thaws set in, streams flowed throughout camp. Many streams made their way beneath buildings. In these cases, it was necessary to divert the water before damage could occur. "Although insulation in the form of dirt was added, it was not added to sufficient depth and it was not of sufficient porosity to be considered good fill. Although ditches were dug and dams built, the ditches and dams were not 100 percent effective. It might be stated that, although permafrost is evident throughout the camp area, the soil containing the permafrost drains fairly well when given the chance. For this reason drainage was given top consideration. Soil that became dry subsequent to cutting off the source of water was stable."[5] It is interesting to note that almost any material will serve as a foundation in the antarctic provided it is insulated from the sun's rays and the heat of buildings. Even in cases where snow was mixed with fill material, the foundation remained firm provided a heavy insulating layer of stone was placed over it and running water did not undermine it.

Recommendation

It is strongly recommended that a study of the insulation of foundations be made. It is not uncommon to see, in McMurdo Sound, a pile of unmelted snow perhaps 2 feet high covered by a plank. The ground all about the pile will be bare of snow. It is understood that settling of Little America buildings could be halted by covering the snow surrounding the foundations with excelsior.

Little America

The campsite was prepared by rolling with a D8 and steel rollers. The sills for the buildings were placed according to building dimensions (20 feet by 4 feet). This located the sills (4-inch by 8-inch by 5-foot) farther apart than they should have been, causing the stringer (6-inch by 8-inch) to be placed about 6 inches off-center on the sills. This type of sill appeared to be the most satisfactory method of foundation construction in the Little America area due to the texture of the snow.

All buildings except the recreation building, the powerhouse, and garage were constructed on these foundations. Snow sills (6-inch by 8-inch) were attached to the snow pads and the floor trusses were placed on 4-foot centers on the snow sills. The powerhouse, because of the weight imposed on the floor, had the floor trusses placed on 2-foot centers, while the garage utilized 8-inch by 8-inch by 20-foot timbers in lieu of floor trusses. The recreation building was set on a foundation consisting of freight pallets, as no foundation materials had been provided.

In the erection of the Clements and T-5 buildings for Deep Freeze II and III, the same system of laying sills was used. The foundation for the Jamesway tents consisted of three longitudinal rows of 4-foot by 4-foot pallets. The floor panels of the Jamesways were placed directly on the pallets.

No melting conditions were observed from building heat loss at any time under any conditions. The only melting that was observed occurred when the snow pads were exposed during digging-out operations and were subjected to the direct rays of the sun. The wood retained the heat from the sun and transferred it to the snow surface, which melted. This was noticeable whenever dark or solid objects rested on the snow surface and were subjected to the sun. If a snow cover of at least 12 inches was applied to the affected areas the melting ceased.

When Deep Freeze II assumed operation of the base, it was noted that the galley building was sagging slightly; the lowest point was where the stove and oven were placed. During the course of the ensuing year, the building settled even more. The whole area was completely snowed in. Because of inaccessibility and because the sagging did not pose a major problem, no attempt was made to level the building. It would require a major effort at jacking and shimming. The situation does prove that in galley construction either greater insulation or a much more substantial foundation, or both, should be installed to lessen undermining of the foundation by heat radiation.

Byrd

As the deep snow condition was similar to that at Little America, the same foundation system was employed except for the garage and powerhouse building. Because of the expected live load on the floor of the garage and powerhouse, the steel floor trusses were omitted. The foundation pads and sill were placed in the normal position around the building, but additional rows of pads and sills were placed, with the sill running transverse to the building and 18 inches on center.

During Deep Freeze II 4-foot mud sills were placed on the snow about 2 feet apart on each side of the building. Eight-by-eight beams were laid and leveled across the approximate center points of the mud sills. The 2-foot-high steel flooring support beams were placed every 4 feet along the length of the eight-by-eight beams, then the Clements building floor panels were laid on top of the steel beams. Subsidence was noted toward the end of the year in the powerhouse beneath the generators. The weight of the generators, vibrations, water which leaked through the deck when the snow melter overflowed, and radiated heat probably accounted for this settling. A slight degree of subsidence was noted on one side of the building which housed heavy meteorology equipment.

South Pole

The foundations of the Pole Station buildings varied. The mess hall, head and science building had floor trusses supported on rows of snow sills. The barracks, barracks Jamesway and inflation shelter had foundation timbers placed directly on snow, with no floor trusses. The garage had snow sills, timber cribbing and a layer of broken panels as insulation under the deck itself.

In no instance was there any evidence of settling during Deep Freeze II. Because of this, floor trusses are considered unessential except under buildings where a large refuse pit is needed. All of the 12-foot-high buildings (except the inflation shelter) were erected in excavated pits to keep the roofs of all buildings at the same level. The buildings in the pits are expected to settle less because the bottom of the pit was compacted by the tractor during excavation. Settlement should not be a practical problem at the South Pole, especially when compared to burial by successive years of blizzards.

During weather when there is a considerable variation between the surface snow temperature and the snow temperature two or three feet beneath the surface, as there is in December, the mixing of the surface snow with some of the colder snow results in the mixture setting up and becoming very hard. This principle should be followed in the preparation of the snow surface for building foundations.

Wilkes

For the main station buildings a mudsill type or floating foundation was used consisting of timbers laid upon coarse to fine gravel. The floor girders were then laid upon this foundation and the building erected. All the buildings of Wilkes Station were erected over bedrock, which had coarse to fine gravel and dirt overlying it. This generally varied in depth from one to five feet. Permafrost appeared approximately three feet below the surface.

The temporary camp, consisting of Jamesway huts, was erected on a snow and ice field. Due to the dark green coloring of the huts, considerable heat from the sun was absorbed during the summer season. This caused the snow, over which the hut was built, to melt, starting at the outer edge and working inward as the season progressed. During late summer the sunward side began to appear on a snow and ice pedestal. Melting away can be controlled by heaping snow around the hut. The same problem was encountered with timber foundations for antenna masts located on a snow field and also for timber-type deadmen used in conjunction with the mast stays. This was controlled by heaping snow around the base of the mast and over the deadmen. The method is satisfactory only because the summer season is short. It is recommended that foundation timbers, deadmen, etc. located on snow and/or ice fields be painted white to minimize absorption of the sun's heat.

Hallett

The building foundations were considered adequate. No appreciable sinking or raising of any building was noted. These foundations were placed on snow-free ground.

One condition noted during the wintering-over period, however, was that of fuel consumption. It was found that less fuel was required to heat a building located directly on the ground than was required to heat a building of equal size that was raised on trusses.

TENTS

McMurdo

Communications utilized a two-man Abercrombie tent during the pioneer phase. On 21 January 1955 the communications center was moved up to the site of the permanent camp where two ten-man tents were joined together, a plywood deck built, and a potbellied stove added. Under the conditions which existed at Hut Point during the first weeks, the single radioman on duty spent over half of his time trying to fuel the stove or keep the tent from blowing down.

Initially, a ten-man tent at the Hut Point camp site was used as a sick bay. A diesel fuel-burning Yukon stove was provided for heat. Pitched on snow, the tent had no deck to cover the snow. Without windows, the tent was inadequately illuminated by a gasoline lantern. The space was inadequate for the care of a bed patient. The snow deck melted out beneath the stove, making its use hazardous. With the stove on, the average temperature within the tent was about 35 F, which is too low for the care of either ambulatory or bed patients.

Later, one-half of a tent (FWWMR, General Purpose, Medium) was assigned for use as a sick bay. This gave a 16-foot by 16-foot enclosed space with 5-foot side walls and a peaked overhead, which was adequate for the requirements of the camp at this stage. Though pitched on snow, the tent was provided with a plywood deck. Plastic window panels admitted adequate light for working. Thus arranged, the sick bay was adequate for a shore party of 90 men with close support from ships.

At the outset, personnel lived in ten-man tents pitched upon the snow. Sleeping bags and air mattresses were issued and, in general, the men slept upon the snow. "The tents were unlighted and unheated, for heat would cause everything to sink, making it necessary to move the tent every few days."[7] As supplies arrived in camp, improvements in quarters were possible, including improvisation of decks and sleeping racks and stoves. In the unheated tents, air temperatures were close to the ambient, usually between 20 F and 35 F. The tents did provide excellent wind protection, if properly secured.

Beardmore

A tent was used to house the generator which gave power. Another tent was used for storage.

South Pole

During the construction of McMurdo it was realized that there was little room for tent life during an all-out construction effort in cold weather. A man can put in long and arduous work days in extreme cold if he has a place to warm himself periodically and if he can relax after work and sleep in comfortable quarters. Tents were used for berthing only until the Jamesway Huts were erected. They were comfortable although cold.

CLEMENTS BUILDINGS

General Comments

This building was designed by the Bureau of Yards and Docks as an answer to the various requirements of the IGY to solve the housing problem of the Deep Freeze program. They are constructed of 4-inch panels. The outer surface is plywood painted international orange and the inner surface is plywood covered with a thin sheet of aluminum. The space between the inner and outer surfaces is taken up with 2-inch and 4-inch stiffeners and spun-glass insulation. The buildings were constructed on foundations of snow pads and snow sills upon which floor trusses on 4-foot centers were placed. The deck panels were placed on the floor trusses and clipped together. Then followed the wall panels, after which the roof trusses were set in the grooves provided at the top of the wall panels on 2-foot centers, and the roof was placed on the roof trusses.

McMurdo

Once erected, the Clements Buildings were suitable, but many constructive criticisms can be made concerning the structural and practical construction aspects of the building:

1. The building panels should have been packaged in groups for each building. As much time was spent in gathering panels for any one building from the myriad of bundles in which they were received as was spent in erecting the building. In preparing the buildings for the South Pole Station all the panels for one building were packed together and marked. The savings in man-hours expended was tremendous.

2. The inaccuracies in fabrication of the individual panels caused serious delays in erection. Plywood covering and splines overhung panel

edges so that proper joining of panels was impossible. Before panels could be put in place, many had to be planed down, even sawed in several cases. Often clips and splines did not match so that they had to be removed and/or replaced.

3. The building is overdesigned. The panels could be cut down in weight and retain sufficient strength. Since only a portion of the roof trusses arrived due to a train wreck in the States prior to departure, every other truss was eliminated, placing 4 feet on center rather than 2 feet.

The subject of overdesign could be extended to one of overprefabrication. Flexibility in this type of operation is paramount. Too often a spare planned for one purpose is used for another. Stoves or utilities planned for one space have to be moved to another space. It is much easier to cut a hole in a panel in the field than it is to jockey special panels around to make them fit. Special panels are too expensive. Changes in interior arrangement negate the value of prefabrication. Interior partitioning and studding could well be shipped in economical sizes, as they must invariably be cut in the field anyway. Prefabrication of counters other than the special galvanized tops is a waste of money.

Once the buildings were erected they were warm and stable in high winds. One 50,000 Btu space heater will heat a 20-foot by 48-foot building in the coldest weather. High winds will cause greater oil consumption but this is true in any building. In spite of caulking all roof joints prior to covering the roof with tarps, the roofs leaked during the summer months. A pitched roof is the only satisfactory type for this kind of building. Interior joints were taped with a pressure sensitive tape which cut down heat loss a great deal. Also, tar paper and linoleum on the floor helped prevent uncomfortable drafts. Outside vestibules were prefabricated and erected on most buildings.

In June 1956 the buildings were subjected to winds of 88 to 90 mph and, although there was much creaking and groaning of the buildings, no damage was incurred.

"The Clements is warm and adaptable for practically any size building and purpose. We experienced no difficulty with clips. We did experience difficulty with faulty workmanship in the panels, some plywood sheathing being off as much as 3/8 inch, causing great difficulty in erection and necessitating planing and sawing in order to make panels fit. Roof panels had to be secured to roof trusses with screws. Roof panels tend to lift with winds of 60 to 70 mph. Roof panels had to be caulked and sealed and tarps had to be battened to the surface to prevent leakage.

"Tiedowns were used for all Deep Freeze buildings built on floor trusses. The heads proved extremely susceptible to wind, as they were 12 feet high and on trusses.

"The buildings, excluding interiors, were erected rapidly, taking a total of about 120 man-hours to erect the 20-foot by 48-foot shell. The foundation took approximately 40 man-hours of this time."[5]

Little America

Care must be taken to insure that the first row of roof panels are straight, or the last row will overhang. All clips should be tightened after all roof panels are in place. It took approximately 80 man-hours to erect a 20-foot by 48-foot building. This time could have been shortened if the panels for one building were packed in several bundles and marked as such, instead of each bundle containing panels for different buildings. Also there were panels that had the oak splines missing or attached to the wrong end, necessitating removal and attachment to the proper place.

"The Clements appeared to be a very adequate building and its panel arrangement made it fairly easy to construct. The workmanship on some of the panels was very inferior. A number of panels were not cut square, preventing them from effecting a proper fit. In many cases you could see light through the joints. This was especially bad on the roof because it permitted heat to escape, causing the snow to melt. Consequently, all of the buildings at Little America leaked like sieves. Door latches were not provided, so a piece of bar stock was used to fashion a dog-type latch. A regular walk-in refrigerator-type latch would be more suitable."[8]

The present interior partitions are satisfactory, however it is doubtful if as many roof trusses are necessary, as no snow load accumulated on the roofs. Canvas was installed on all roofs to minimize leaking during warm weather. During the winter, frost and ice accumulated under the canvas covers and with the return of warm weather the ice melted, causing numerous leaks in the buildings and necessitating the removal of the canvas and cleaning of the roofs.

During Deep Freeze II, one proposed solution to the problem was to caulk the joints with a low-temperature asphaltic compound. Cracks appeared in the compound, however, during extremely low-temperature periods. Also, if any load was applied to the roof (snow accumulation, personnel walking), the caulking fractured. Slanted or peaked roof buildings might be a solution.

The heating was satisfactory, as was the light and ventilation. There was a heat differential of approximately 20 degrees between the floor and the roof, but this was not uncomfortable. All thermostats were set at 70 degrees. Proper ventilation of buildings was a constant problem. The very nature of the insulated buildings tends to keep all odors

and stale air bottled up. Fans on either end of the buildings alleviated the problem somewhat, but a direct intake from the supercooled outside air cannot be used constantly. The ideal situation may be to take in the relatively warm air from the passageway and exhaust directly to the outside. This method, however, wastes the heat which otherwise may be used to take the chill off the main passageway. Perhaps a heater designed to pull in fresh air from the outside and exhaust directly into the tunnel would be the answer.

Lack of moisture was a most noticeable deficiency. In an attempt to introduce moisture into the air in each building, metal containers were hung on the front of each heat register. The containers each held about a quart of water and as the warm air passed through the register it agitated the water and introduced moisture into the air. This method brought the moisture content in each building up from 12 to 22 percent.

The use of this type of building for a function with a high noise level, such as communications, presents poor working conditions. The lack of windows, the sheet aluminum finish on the walls which reflect noise, and poor ventilation are features of the construction which contribute to strained working conditions.

The building interiors were, for the most part, changed very little during Deep Freeze II. However, in one newly erected quarters building a modification to the cubicle arrangement was made. The occupants elected to have the open-type barracks arrangement with the lockers acting as roomette partitions. This allowed a much larger recreation area, which was much used by all.

The deck surfaces posed a problem to the proper cleaning of spaces. The clips used to connect the floor panels together are recessed in the plywood wearing surface. These recesses are natural depositories for dirt and debris. Plywood plates were fabricated for insertion in these recesses so that linoleum could be laid without danger of its being punctured. Linoleum or asphalt tile as a floor covering not only facilitates cleaning, but also brightens up the building.

"Ground rods were not used to ground building electrical systems because of the inability to obtain an effective ground in the snow. When the problem of grounding arose, I advised the Chief Electrician to ground everything to the sheath of the M.I. cable, and then ground the cable sheath to the base of the generators."[8]

South Pole

The Clements Building is without doubt the superior structure in all respects. The flat roof is of paramount importance since from it the snow blows clean and no strain is put on the roof. The building is

spacious, light, clean and warm. The plywood decks of the Clements Buildings were very rugged and firm. The main drawbacks were the cleat holes, which collected dust and debris, and the plywood decks which soaked up diesel oil tracked in from work areas. Both these difficulties were overcome by covering the decks with linoleum. Linoleum makes cleaning and sweeping vastly simpler and quicker, it reduces fire hazard by being nonabsorbent to oil, it covers cracks which may let in cold air, and it adds cheerful color to the otherwise drab surroundings. In laying the linoleum, no linoleum paste was used, since the paste hardened so rapidly on the cold decks that it was impossible to get the linoleum on in time.

Hallett

The Clements Buildings were found adequate and kept heat well. The only drawback was during storms when snow would get into the buildings through small openings around wire, slits in the doors and panels, and through exhaust fans. Snow which collected on top of the roof would melt and leak through slits in the panels.

Wilkes

The Clements huts were not entirely satisfactory and had several shortcomings. The roofs leaked during the summer melt and arched considerably in high winds when the windward doors were opened.

The quality of workmanship on the huts was poor in some cases. The exterior panels often had the clip slides misplaced. The prefabricated interior partitions were so badly sized that they could be used only as plywood sheathing on conventional 2 x 4 studs. Some key panels in specialized buildings were missing and this caused the employment of jury rigs, which were unsatisfactory. Clips tended to loosen during high winds because of vibration. Some type of lock would be desirable. This was particularly evident on the aurora tower, which lost eight clips during one storm and had to be structurally strengthened while the storm was in progress to prevent serious damage.

The door latches were often difficult to operate, as a small amount of ice or snow would prevent them from closing. This was aggravated by the installation of exhaust fans directly over the door, where they would melt snow and cause icing of the doors.

The constant presence of water on the deck of the garage eventually caused the plywood to become very soft and resulted in considerable damage to the panels. The garage doors were modified when installed to open against the walls instead of against the roof so that a M29C and a 955 Traxcavator could be kept in the garage at the same time. This installation was satisfactory except that there was quite a bit of snow leakage around the doors. The use of some type of lightweight folding doors might have reduced the leakage somewhat.

The buildings were comfortable to live in and the feeling of extreme dryness usually noticed during the winter in heated buildings was not present. The vinyl tile decks stood up well under severe usage except in extremely wet locations.

The station layout made no provisions for blowing and drifting snow. All doors on Clements huts face either directly toward or away from the direction of our blizzards. In the first case, the door cannot be opened during a blizzard for fear of losing the roof, while the doors facing the leeward side are rapidly covered by drifts. This problem was solved at Wilkes by building an escape hatch on top of one tunnel and building a side extension to the main tunnel to open at right angles to the direction of strong winds.

TUNNELS

Little America

Tunnels were constructed of 2-inch by 4-inch wooden framing set on snow pads. The roof consisted of 2-inch by 10-inch timbers set on 2-foot centers. The framing was covered with chicken wire and burlap. An electric fixture was installed every 20 feet. The snow accumulation along the sides provided an effective insulation. However, with the return of warm weather the snow accumulation on the roof melted and leaked through the burlap. This caused the deck of the tunnel to become coated with ice, creating a hazard. Other than the leaking conditions, the tunnels were very satisfactory. The temperatures were at least 20 degrees warmer in the tunnel than outside. However, it is believed a lighter design would suffice and the roof should be sheather to prevent leaking during warm weather.

On two occasions during the winter night, high winds blew off small portions of the burlap covering the Kiel Field tunnel. This resulted in the tunnel being completely filled with snow. This was dug out by hand because the large amount of aviation stores in the tunnel would not permit the use of the D4.

Byrd

The columns of the tunnels were constructed from three oil drums welded end-to-end, forming a member 10-1/2 feet high. These columns were set 8 feet apart, center-to-center. For long spans, 1-1/2 and 2-inch pipe were used; for short spans, 1-inch pipe and 3/4-inch rod were used. Where the pipe or rod rested on a column or another pipe or rod, the connection was welded. Two by fours and scrap lumber, spaced about 2-1/2 feet apart were also used for framing. To save material, the fronts of the buildings were used as one side of the tunnel. Chicken wire was

secured over this frame. Parachutes, recovered from airdrops, were layed over the wire and anchored. Drifting snow caused the tunnel roof to collapse in several places. Reinforcement, usually empty fuel drums, contained the loads until the weight of snow stabilized.

South Pole

The tunnel design was changed from the original plan to conserve lumber and provided over 10,000 square feet of tunnel, most of which was 10 feet high. By fastening all tunnel roofs on one side to adjacent buildings, over 400 feet of tunnel wall was eliminated. By making tunnels at least 8 feet wide, additional savings were made. The original plans called for 8750 square feet of tunnel and 1440 linear feet of wall. The resulting tunnels had 10,060 square feet of tunnel and 1008 linear feet of wall.

The 2-inch by 4-inch stud wall sections were prefabricated on the ground and raised into position on 2-inch by 10-inch by 16-inch pads. Chicken wire and burlap were stapled to the frame. The burlap proved to be quite impervious to blowing snow and wind, and reduced the constant digging out of material stored within the tunnels. The fuel demands for heating buildings were reduced considerably by the installation of the tunnels.

Recommendations

1. That all tunnel walls and roofs have studs/joists on 2-foot centers. Greater spacing will not provide adequate strength.

2. That all tunnel roofs and walls, including leeward walls, be covered with one layer of chicken wire. All windward walls and all roofs should be covered with one or two layers of burlap and one layer of parachute cloth. Leeward walls do not require parachute covering. The two layers of burlap are needed for insulation. The layer of parachute cloth provides wind protection and prevents snow from sifting through the burlap; if adequately battened down, it will prevent the burlap from blowing loose.

Wilkes

The major buildings were connected by elevated wooden tunnels. Such tunnels are an absolute necessity and must be completely windproof. The tunnels were erected of 2-inch lumber framing and 1-inch sheathing, covered with tarpaulins to keep out blowing snow. This type of structure was very satisfactory and was quickly and easily constructed. It was the general opinion at the station that the chicken wire and burlap type of tunnel and storage sheds could not have withstood the winter.

QUONSET HUTS

Quonset huts were erected only at McMurdo and were considered unsatisfactory for antarctic use. No amount of caulking will keep blowing snow from entering this structure as presently designed. Most of the snow is caught in the insulation. As soon as the sun hits the building, the snow melts and the roof drips continuously.

Quonset-type construction, in subzero temperatures, completely tests the patience and skill of every workman. Big mittens cannot be used and frequently bare hands are required to cope with the small nuts and nails utilized in such construction. Numerous cases of frostbite were the result. The 240 man-hours required to erect a Quonset far exceeds the 150 man-hours required to erect a Clements Building. After the Quonset is erected, it is difficult, by comparison, to heat and maintain.

One-inch banding material, spaced at 8-foot intervals, fastened to the outside sills and extending over the top of the roof, prevented the loss of the corrugated sheets in the high winds experienced. "All Quonsets were resealed with mastic and repairs were made to sagging interior roof panels due to heavy snow infiltration."[20]

"Since the Quonsets were to be utilized as quarters for summer months only or for storage the rest of the year, and because the snow load was thought to be light, regular rib spacing rather than 2-foot spacing was used. Also, the huts were insulated in the usual manner, rather than expending the extra man-hours required to put the insulation in as designed. The main heat loss in the buildings was at the doors. Vestibules were added to reduce the loss. The use of electric impact wrenches and hex-head screws helped to speed the erection. The use of standard banding material for tying down corrugated metal sheeting speeded sheet tiedown. Extra screws and cable tiedowns were added to prevent wind damage."[5]

The Quonset is only minimally acceptable as a summer or transient building under the circumstances found at McMurdo. Even then one must accept the leaking roof. Perhaps once a Quonset is buried with snow it would become more suitable for year-round use, but it is doubtful if any building at McMurdo will ever be buried.

MISCELLANEOUS BUILDINGS

Jamesways

Jamesway huts were utilized at most of the IGY stations. They are rapidly erected and are strong and tight. The Jamesways are easy to transport, as no piece is longer than 8 feet. They can also be airdropped. The Jamesway has the advantage over other temporary buildings in that it may be built in increments of 4 feet to any desired length.

At Little America, it was found that the Jamesways were not able to sustain an appreciable snow load. After one blizzard the ribs and purlins began cracking. The clips, which are riveted to the ribs to connect the purlins, were the source of some of this failure. As the weight of the snow was applied to the outside of the building, the purlins began to bend. The inward force was transferred through the purlin to the clip and thence to the rivet holding the clip to the rib. This meant that the weight of the outside snow was transmitted to a very small bearing surface on the rib. The ribs in every case cracked longitudinally along the axis of the rib at the rivets. It is suggested that a different type of connection be fabricated for attaching the purlin to the ribs. A means whereby the whole depth of the rib is used would eliminate the cause of the longitudinal splitting.

At the South Pole, a Jamesway was used in the permanent camp. By surrounding the hut with tunnels, the heating requirement was considerably reduced and the snow load was eliminated. The interior of this building was reinsulated with the felt strips which came with the air-dropped materials. The strips were interwoven between the purlins of the wooden frame as well as layed on the deck and covered with heavy canvas. The canvas was stapled or nailed down over the felt as tightly as possible. This decking was durable and warm.

Wilkes Station reported that the Jamesway huts were in general satisfactory but were very difficult to seal against snow leakage. Ellsworth Station recommended that a larger flash pan be used under the space heaters. The pan should be large enough to contain any fuel leaking out of the fuel tank, and thus prevent the decking from becoming oil-soaked.

Atwell Huts

The Atwell (Shelterwell) huts are classified as temporary buildings. They are erected rapidly and, once erected, are strong and tight. The Atwell takes a little more time to erect than the Jamesway, but once erected, is more weathertight. The Atwell has the advantage over the Jamesway of lower cost, and of lower weight and cube per equivalent size.

Aurora Airglow Towers

In erecting aluminum structures such as the Aurora Airglow Tower in subzero weather, extreme caution is necessary in tightening turnbuckles and nuts, as the threads become very brittle and strip quite easily.

Geodesic Domes

Two 42-foot geodesic domes were furnished Ellsworth for use as equipment-storage buildings. As MCB ONE was unable to complete erection of the domes prior to evacuation, full evaluation could not be made, but it

appeared that they afford a practical solution to the equipment-storage problem in Antarctica. The 8-foot-high by 12-foot-wide doorway in the domes was large enough for weasels to drive through. By compacting the snow in the doorway, D4 tractors could be stored inside the domes.

T-5 Buildings

Experimental T-5 buildings were erected at McMurdo and Little America. They are basically the same as the Clements building, with the following exceptions: The panels are thinner, with a resultant lessening of weight; the roof is a gable type; the joints between roof panels are covered with a weather sealer to provide a watertight joint; the roof trusses are of wood. After one year's occupancy, the T-5 is thought to be far superior to the Clements. Individual parts are tighter, easier to handle, and fit together in a much more satisfactory manner. There was no evidence of leakage, and the thinner panels did not appreciably affect the insulating properties of the structure.

Section IX

UTILITY SYSTEMS

HEATING AND VENTILATING

McMurdo

The predominant heating unit was the diesel Preway space heater, of which one or two were found in all buildings. They operated by gravity flow to a float type carburator which controlled the flow of oil to the fire pot. Fans were usually mounted directly above or close to these stoves to circulate the warm air. The major problem encountered during Deep Freeze I and II with these stoves was the stacks. When there were high winds, back drafts were common. This would cause blow-backs and fill the building with smoke and fumes. To counteract these drafts, a different type of stacks and stack caps were tried. A 6-inch stack was installed from the stove up through and above the roof. On some buildings an 8-inch stack was slipped over the 6-inch stack. This worked on some buildings, but not on all. A round cap with a conical center piece was tried but these caps usually filled with ice or blowing snow. On some of the other buildings, a 6-inch tee for a cap was used with the solid side of the tee set to face the direction from which the strongest winds came. Again this worked on some buildings, but not all. The efficiency of a stack seemed to depend upon the protection given by other buildings and the direction of the winds. The best stack for each stove was determined by trial and error.

Another type heater was the Jet heat automatic oil fired warm air furnace. These heaters were good except when maintenance was required. They contained many parts which had to be disassembled before reaching the trouble. If the heater was turned off and the solenoid valve allowed to become cold, the valve would not operate properly. This caused a lot of trouble in starting the units. However, once running, these heaters required very little maintenance and performed well.

Little America

General heating at Little America was accomplished by the use of Jet heaters and Preway stoves, both diesel fired. The Jet heaters worked satisfactorily. The Preway stove is a space heater type. With the exception of periodic freezing due to accumulation of water in the carburator, operation was entirely satisfactory. Preway stoves were fired only when actually needed, thus most of them were turned off during the night. It was found that upon starting them up after this shutdown period, the cold air from the outside rushing down the stack acted as a damper, and many times smoke backed up into the room. Until the fire reached full intensity and warmed up enough air to push the cold air back, the unit had to be watched, usually for about five minutes.

The stacks were a source of constant concern. Regular inspection was necessary to insure that all pipes cleared the accumulated snow on roofs. Space heaters were found to work more satisfactorily when equipped with double walled stacks through and above the overhead. This eliminated formation of frost on the pipe interior. When the pipes were run through a side panel, ice accumulated at the outer elbow which had to be removed periodically. "Flame out caused by constant high winds meant constant vigilance of heaters."[16]

Kiel Field, Little America

Each building at Kiel Field was equipped with two diesel fuel space heaters which were completely adequate for the heating requirements. The integral fuel tanks for the heaters were bypassed, and fuel was supplied directly from drums of fuel located on racks outside each building. The trap door leading to the control tower was left open allowing some heat to circulate into the tower.

Byrd

Jet heaters were used to heat the buildings at Byrd Station. The fuel supply consisted of one 60-gallon tank located inside the building and elevated some 6 feet for gravity feed. The heat was distributed through ducts and emerged from registers placed throughout the buildings. Exhaust fans were mounted in each of the sleeping buildings to assist ventilation.

South Pole

The Jet heaters were damaged extensively during air drop. Spare heaters were ordered from CONUS but had not arrived prior to departure of the construction force. Spare Preway heaters were procured from McMurdo. Maintenance of the

Jet heaters was greatly handicapped by lack of test equipment and the fact that the UT had had no previous training or experience with the heaters. The Jet heaters were more economical in fuel usage, burning about 5 gallons per day to heat a 20-foot by 48-foot deep freeze building as compared with 8 to 10 gallons per day for the Preway space heaters. Frequent attempts to start a cold-reluctant Jet heater should be avoided since each press of the starting button introduces fuel into the burning chamber, and the final successful ignition may blow the end of the heater off.

Preway space heaters were used extensively during Deep Freeze II and performed very well. ILG fans were installed over each stove to circulate the warm air. Maintenance problems were minor and easily solved. For reliable heating the Preway space heater is considered far and away the best stove provided. These heaters have 5-gallon fuel tanks fastened to the back. The Jet heaters were served by 60-gallon storage tanks mounted on legs to allow gravity feed.

To prevent back-draft the stacks were left vertical with no elbows whatever. To prevent icing a very short narrow-diameter pipe was used. A narrow, heavy gauge pipe tends to store enough heat so that ice will not form even in the coldest weather. A shield was fabricated to surround the pipes from the stoves to head level to protect personnel from contact with hot stove pipes.

The observatory was heated by a tent stove, and warm air was blown by a fan into the adjacent inflation shelter. This system proved highly successful so long as the stove was able to draw air directly from the tunnel system. Otherwise, the exhausting fan created an air deficiency causing the stove to rapidly clog with soot.

The air supply for the Clements buildings was considered in some detail with several recommendations for drilling air vents in the decks near the heaters. However, none were drilled, and there is no forced ventilation to these buildings except in the galley. There, a vent was cut close to the deck by the stove, and an exhaust fan was installed above the stove. In the garage it was necessary to keep the main doors open a crack to cool off the inferno. In the other buildings the air seemed to change rapidly through leakage, and there were no complaints about stale air. In the Jamesway barracks the circulation of air was poor, and it was occasionally necessary to open both doors and let the fresh air in. The ILG jet fans mounted over the Preway stoves would cover local areas well even on low speed, but the remote corners of all the buildings suffered from a certain amount of stagnation. Ventilation in the tunnels was a problem when the station was well drifted over. What fresh air reached the tunnel system entered through the burlap roofing and through several small entrances dug in the snow banks on the grid south side of the base.

Hallett

Jet heaters provided the heat in all the main buildings except the galley and the recreation room. Though they operate satisfactorily, the Jet heaters require more attention and maintenance than is feasible for this type of station. Considerable trouble was encountered in the electrical system, particularly the solenoid on the oil supply system.

Preway space heaters were used in the recreation room and gave excellent performance. They were considered by the station personnel as the most adaptable type of heater for the base. The only consideration required in installation of these heaters was the location of the exhaust stack in relation to the prevailing surface wind.

All fans provided this station were considered suitable. In installation of these fans, particularly exhaust type, the prevailing surface wind direction should be considered.

Wilkes

The Crane Jet Heat furnaces used in most of the buildings worked very well, keeping the buildings quite comfortable. Some difficulty was encountered with the controls but this could usually be corrected by replacing the control unit. Some training on this unit would have been an advantage in caring for them. Objectionable fumes were produced by these heaters when first installed but did not persist. The portable vapor heaters were too cumbersome for interior use and were not needed elsewhere. The small pumps installed on these heaters were put to a variety of uses.

The Preway space heaters were simple in operation and usually worked well, but they had a dangerous tendency to reverse draft in high winds, shooting smoke and flame into the buildings. For this reason they were replaced with Jet heaters when units were available. The heat from the generators served to heat the powerhouse and for most of the year, the garage.

The Clements huts were very comfortable. Constantly running exhaust fans, with occasional flushing by intake blower fans, kept the air fresh. Temperature stratification in the buildings did not become a noticeable problem, probably because of relatively low inside temperatures and relatively high outside temperatures as compared with other bases. The maintenance of inside temperatures at +65 F or below is very strongly recommended. Dryness of the air was not a serious problem, due partly to the relatively warm, moist air found near open sea water, partly to the vapor barrier built into the huts, and partly to the below +65 F inside temperature.

Ellsworth

Heating of most buildings at the station was done by Jet heaters. These produced a very satisfactory amount of heat even on the coldest days. They required little repair and were economical on fuel. The space heaters were less useful. They could only be used adequately in buildings that did not have partitions in them. They burned more fuel than the Jet heaters to produce an equivalent amount of heat and required more repairs. Both types of heaters reduced the amount of water vapor in the air and caused nasal dryness. If the station is kept in operation an attempt should be made to install and use the humidifier that came with both types of heaters. Ventilation of buildings using intake and exhaust fans worked satisfactorily when the outside opening was either in the tunnels or outdoors.

Several accidents occurred during the refueling of heating units. Fuel oil splashing in eyes and barrels of fuel rolling onto persons moving them were always a potential danger. It would be time-saving and less dangerous if fuel lines were run from the fuel supply to the fuel tank in each building.

Recommendations

1. That flash pans large enough to extend under fuel tanks of space heaters in the Jamesway huts be provided.

2. That a spare fuel line solenoid valve be packed with each Jet heater.

POWER GENERATION AND DISTRIBUTION

McMurdo

Generation

Three 100kw Caterpillar (D-342 diesel engine) generator sets were installed at McMurdo in Deep Freeze I. Originally two generators were installed in the powerhouse and wired to permit paralleled operation if desired. The third generator was installed in the galley to provide emergency operation in the event of failure at the powerhouse. They are 3-phase, 110- to 208-volt units with apparent power output of each leg not to exceed 346 amps. The primary difficulty experienced was that of paralleling the units. However, the problem was never completely solved as the governors were unreliable permitting wide variations in frequencies. The generators are all connected to a control bus bar system from which seven external

circuits are run. Under load, there is little difficulty in paralleling the generators once a few precautionary measures are taken by the operators. Each generator will consume about 4.25 to 5.20 gallons of diesel fuel each hour and about 0.15 to 0.20 quarts of lube oil each hour under loads varying between 250 and 600 amps total. During very small loads, diesel fuel consumption falls to 3.0 to 3.6 gallons per hour and lube oil consumption appears to rise somewhat.

There was no set pattern for power demand. The curve (for power consumption) shows a drop during nonworking hours when working on a single shift basis. However, when working on a two shift basis, the curve has no definite pattern. The demand normally varied from 250 to over 600 amps. Therefore, only one generator had to be on the line at any one time. During the summer months, with 24-hour air and construction operations, the load varied between 400 and 750 amps.

Certain pieces of electrical gear at McMurdo were sensitive to voltage changes (i.e. aerological radar and communications equipment), and others demand a great deal of current (i.e., the 400-cycle motor generator). Communications and aerology were normally notified whenever a change in voltage might occur, as when generators were being switched for maintenance or when a heavy load was being added to the line. These departments could then guard against overload or a drop in voltage. Transformers and compensating devices were ordered for Deep Freeze II to alleviate voltage drops when heavy loads are thrown on the line.

Even in the summer when the load was heaviest with an average maximum daily power demand of 92 kva, operation of one generator at a time was permitted. The two generators were alternated on a weekly basis. Only one generator failure was experienced during the summer when a generator fan showed evidence of disintegration, apparently from fatigue. The diesel engine on one generator was in need of overhaul in late January 1957 after approximately 4000 hours service. A new load of about 30 kva was to be added upon completion of the new communications setup. This would necessitate operation of two generators constantly, as the total demand would be in excess of 120 kva. For this reason steps were taken in January to relocate the third generator to the powerhouse.

While it was theoretically possible to operate the generators in parallel, in practice it was a hazardous undertaking. This appeared to be the result of complete unreliability of the governors after a few months of service. The resultant frequency variation had to be closely watched. Any attempt to operate the generators in parallel could well result in complete loss of one or both machines. For this reason, the generator connections were modified to permit independent operation of generators under all load conditions. With this system no generator was loaded beyond its 100kw capacity. The system was being installed when Detachment One departed

Antarctica. Since sufficient group-operated switches were not available, individual switches were placed everywhere except at the generators. This should be rectified by provision of six air-break, group-operated switches.

The governor variation appeared to be a chronic fault with all of this type generators. Even operated independently, this was a source of constant worry. Radio communications and aerological operations require a reliable voltage and frequency. Consequently a constant qualified watch on the generators was necessary to make adjustments. All efforts to permanently correct the variation were unsuccessful.

Two generators were hooked to the transmitter building bus, through a series of switches, during Deep Freeze II. By this arrangement, one generator could carry the load of the base, and another generator the load of the transmitter building. However, this feature was never employed as the load of the base and transmitter never exceeded the limits of one generator. Each generator ran continuously for a two-week period. Overheating of the engines caused by the powerhouse watch failing to allow adequate ventilation caused most power failures, for the engines shut off automatically when overheated. The only trouble encountered with the 100kw units was ice forming on the slip rings and brushes during blowing snow conditions causing a disruption in power. Heat from a Herman-Nelson heater directed on the brushes easily restored power.

The 30kw Caterpillar (D-315 Engine) Generator sets are single phase 110/208 generators. As such, they could not be used in conjunction with the base electrical system. All three were thus scheduled for the South Pole Station. However, one was used at the runway for GCA tower and line operations power supply. This unit was not entirely satisfactory for GCA work as the governor permitted undesirable and critical variations in frequencies. Another trouble experienced with this generator was blowing snow getting into the generator and causing the brushes to stick. This was overcome by covering the entire unit with a canvas cover. The 30kw generator consumed approximately 22 gallons of diesel fuel each day at low load.

Quite a bit of trouble was encountered with the Hobart 10kw generator sets. These units are gasolene-driven, generating at 220V, 60 cycles, 3 phase. The engine failing to hold the load caused most of the trouble, due mostly to spark plugs which had to be changed about every 60 hours. Fuel pump trouble was overcome by installing electric fuel pumps. Snow and ice on the slip rings and brushes was also a problem. Fuel leaked into the crank case of one unit and the engine froze. This trouble was never overcome. Two units were located at the control tower, and two were installed in the transmitter building as an emergency power supply. Because of the unreliability of the 10kw units, their use was discontinued early in October 1957 and battery power substituted until 30kw three-phase generators were installed in late October and mid-November, respectively.

Distribution

Originally there were seven primary circuits at McMurdo:

Circuit No. 1 - Powerplant, URN-5 homer, and five Jamesways (Bldgs 38-42)

Circuit No. 2 - Buildings 15-24

Citcuit No. 3 - Garage, parachute loft and aircraft fuselage

Circuit No. 4 - Mess hall, storage Quonsets, reefers

Circuit No. 5 - Aerology, quarters, administration and sick bay, library and offices, latrines, dog kennels and inflation shelter (16 bldgs)

Circuit No. 6 - Communications (34)

Circuit No. 7 - All aircraft support buildings (36, 43-48), and chapel

During Deep Freeze II, circuit no. 8 was added and the connected load partially redistributed between the original seven circuits. The revised circuitry was as follows:

Circuit No. 1 - Powerplant, homer beacon, and six Jamesways

Circuit No. 2 - Buildings 15-22, 35, and recreation hall

Circuit No. 3 - Garage (new), parachute loft, reefers

Circuit No. 4 - Mess hall, buildings 13, 14, Jamesway building 9

Circuit No. 5 - Building 1, Atwell huts nos. 2-7, aerology

Circuit No. 6 - Communications, three cables

Circuit No. 7 - All aviation buildings, three cables

Circuit No. 8 - New transmitter building

Mineral insulated direct-burial type cable was used for all main power lines. Since each circuit was laid out after the permafrost had risen almost to the surface of the ground, complete burial was not practical. The lines were laid on the surface except at intersections with roadways where they were run through buried hose or conduit. There were over 75 splices in the circuits. Much work is anticipated in resplicing and burial by Deep Freeze II forces. Proper splice boxes were not available to Deep Freeze I forces. The value of the MI cable for long runs is questionable. It is believed that overhead wiring would have been more satisfactory for this base if the interference with radio transmissions could be eliminated. In spite of efforts to prevent it, there were many instances of cutting the power lines creating a hazard to personnel in addition to a lot of work in splicing.

Electrical distribution during the summer of 1956-57 was a severe problem, one which might have easily reached dangerous proportions. This was almost entirely due to the absolute unsuitability of mineral-insulated cable for this specific locality. Doubtless this conductor would be satisfactory if the entire system were enclosed. However, the McMurdo base does not have tunnels, and long runs outside were necessary. Troubles with this cable can be catergorized as short lengths and splices. At the size necessary (numbers 6 and 8) the maximum length available is 160 feet. This necessitated numerous splices, most of which were exposed to the weather. The splices recommended are extremely time-consuming and difficult to make, particularly in cold outside air. None of the splices proved to be waterproof.

Problems with this system were further aggravated by the lack of proper burial. Because of the late unloading of ships (in 1955-56), it was impossible to install the system until the frost level neared the surface. Therefore, heavy equipment operating in the area was a constant hazard to electric lines. But the real trouble developed with the coming of the spring thaw. Water penetrated the splices, causing shorts. Outages were a daily occurrence. Electricians were constantly battling to maintain essential services. It was necessary to dig up every splice and put them above ground to defeat the menace of water. The system is now exposed and totally unsatisfactory; all heavy equipment has to be restricted from operation within most of the camp.

"The powerhouse is located some distance away from the main camp area. This necessitated a great deal of splices in the MI cable. Splices were made in the cold in fabricated wind breaks. Inevitably, however, splices would not ring out due to dampness, etc. One solution used was to use all four conductors in the MI cable for a single phase. The outside copper protective sheath was used as the ground. This simplified the splices and eliminated the chance of shortages due to vehicles damaging the cable. This, in effect, was using the expensive MI cable as one would use any direct burial cable. The MI cable should be eliminated and standard burial cable should be substituted."[5]

Because the new Deep Freeze II transmitter building was located about a half mile from the main camp, it was necessary to supply it with external power. The power line was placed on 20-foot wooden poles previously used as fenders by Deep Freeze cargo ships. The poles were spaced 50 feet apart and sunk about 2 feet in the permafrost or ice and guyed. Each pole had a single cross arm with the power line on one side of the cross arm and the keying line on the other side to balance the pole. The power line was unsupported. The wire provided for the 4160-volt power line was a 3-conductor jute-insulated type designed for use in underground ducts. The constant high winds caused vibration of the wire and poles which shredded insulation and broke conductors.

In May 1957, a blizzard with a gust of 83 knots blew down one pole and 800 feet of power line. In June another blizzard blew down two poles, parted the power line in several places, and blew it off seven poles. Two 10kw generators were moved to the transmitter building for emergency power while repairs were made.

For a while it was undecided as to how to repair the broken power line. Various schemes were put forth, such as replacing it with three strands of no. 6 copperweld, thus providing a bare power line. However, it was considered too dangerous to have a power line of this type exposed to personnel. It was finally decided to remove the power line from the remaining poles and to splice the existing power line with rubber electrical tape. When the weather warmed up during summer operations it was necessary to put several of the splices up on boards to keep them out of puddles of melt water. It was recommended that heavy armored ground cable or proper aerial cable be procured for Deep Freeze III as a replacement.

Another problem encountered with the power line was the voltage drop. There was a 20-volt drop per phase in the power line. The FRT-24 required 230 volts in a single phase. The normal voltage supplied per phase was 208, or just within tolerance. This voltage drop problem was never solved. The only solution would be to put the transmitter building on its own separate power supply. It was anticipated that the total power requirement of the transmitter building under full operation would be 55 kva, and it was recommended that the power cable be capable of carrying this load.

Effects of Cold on Certain Electrical Materials

Thermoplastic Insulation, when exposed to cold weather, became brittle. Bending of the wire would cause it to crack and flake off. The Neoprene insulation lost some of its flexability. This made it hard to apply on the small gauge MI because of the annealed wire. Sealing compound for MI cable became hard, and difficult to apply. Friction tape would not stick well and, while unrolling, would tear in narrow strips.

Electrical Characteristics

Not much can be said regarding electrical characteristics because of the paucity of metering and analytical equipment. The only panel metering located in the powerhouse is generated voltage, total current per phase, and frequency. Another place where voltage was an obvious problem was at the aviation shop. A 50-horsepower motor caused severe voltage drop, particularly in starting.

Recommendations

1. That the entire electrical distribution system be replaced. From an electrical and physical standpoint the most satisfactory system would be overhead. A messenger supported cable system on poles should be very satisfactory. However, such a system is not acceptable to communications. It is feared that the overhead lines would create intolerable interference. Therefore, the most satisfactory acceptable solution appears to be a properly designed underground system. Investigations should be made to select a cable with cold weather characteristics which can be procured in long lengths, excluding splices except at junctions. At these points, junction boxes should be placed which will permit splices to be made above ground. Provision for draining the junction box must be made. Steel conduit should be provided for road crossings and other areas where heavy equipment may be working. The system should be installed in late December or early January when the permafrost level is deepest. At this time the ground is relatively easy to ditch and the cable can be properly buried.

2. That adequate metering be installed to properly analyze electrical performance. This would include power factor meter and recording meters for current and voltage for each circuit. Portable meters should be provided for recording current and voltage at the load end. These should be in addition to the existing clip-on type indicating meters.

3. That a voltage regulator or capacitors be provided at the aviation shop to compensate for the drop.

Little America

Generation

The powerhouse is a 20-foot by 48-foot building set on floor trusses centered 2 feet apart. No foundation difficulties were experienced. Power is derived from five three-phase, 30kw, 120/208-volt generators with a remote control panel. Each generator has the capacity to produce 104 amps per phase at 80-percent power factor.

The control panel and corresponding generator are tied together with no. 4 RH wire in a 2-inch conduit. This wire should have been at least no. 2 because the alternators are rated at 104 amps per phase, and no. 4 wire will not carry the load. This caused an extra alternator to be on the line 50 percent of the time and raised fuel consumption. The bus bar consists of four 350-MCM wires, to which all sets are paralleled. From the bus bar to each of the distribution lines there are 100-amp fuse boxes for circuit protection. Each building is fused. All buildings, lights, and equipment, etc. are grounded in a loop ground system.

When the diesel electric sets were put into use it was found that the automatic voltage regulators did not function properly. This was true for both Deep Freeze I and II. The voltage would not come up to the right level with or without a load on the line. The exact trouble could not be determined as no dc volt meters or dc ammeters of sufficient capacity were available. To try and correct the problem, the governors, voltage droop and voltage level adjustments were all reset according to Caterpillar Serviceman's Reference Book. They were then put on the line and still would not parallel without making additional adjustments by hand to the voltage level. Knowing that no such adjustments should have been made, further information was requested from the Bureau of Yards and Docks. Following the instructions and using snow melter immersion heating units for load, each unit was set individually at the same voltage. Tests were made to parallel two or more alternators with the same results. The generator would go on the line, but would get a very high ampere reading from the ammeters on the panels. This method of adjusting the units was tried several times with the same results.

The following is the method that was used in paralleling the D-315 diesel electric sets:

1. Start main engine and let run at half throttle for approximately 15 minutes until temperature gets to operating range.

2. Turn knob of governor until frequency meter reads 60 cycles. This gives approximately 190 volts on panel meter.

3. Adjust voltage level screw on generator set until panel meter reads 210 volts because if it is put on the line at 190 volts the voltage will be too low and will pull down the voltage of the other generator.

4. When synchronizing lamps go out, push the circuit breaker switch to the "on" position; this puts the generator on the line.

5. If the ammeter hand on the panel starts rising, remove the generator from the line by opening the circuit breaker.

6. With circuit breaker open, the voltage according to the reading on the panel board volt meter would jump up, sometimes as high as 240 volts.

7. Reset voltage level screw on the generator to 210 volts. Push the circuit breaker to the "on" position, thus putting the generator on the line.

This is the same method used by the Caterpillar representative, while at Little America. Although he used several different voltage levels and voltage droop settings, the results were the same as the ones previously used. Generators had to be adjusted individually to permit paralleling. The Caterpillar representative stated the source of the trouble was in the exciter.

After a considerable amount of time was spent during Deep Freeze II trying to correct the trouble with the regulators, it was decided to replace them on three of the generators with new regulators. This, however, was never done. Instead, three complete new generator units were substituted. The new units were given the same tests as the old ones and the results were the same. It was then decided that the best solution to the problem was to zone the base into three electrical sections, completely independent of each other. To accomplish this, two more generators would be needed. This meant constructing an annex to the present power plant, including switch gear and bus bar.

For this annex it was decided to convert the electrical equipment storeroom, which was adjacent to the main plant. To support the weight of the generators, the foundation had to be reinforced with 8-inch by 10-inch timbers and decked over the 2-inch by 8-inch planking. Two of the old generators were brought in and bolted to the new foundation. The bus bars were constructed out of solid copper ground rods. On the framework was mounted the switch gear for the generators and disconnect switches for the feeders. The approximate time required to complete construction on the annex was two weeks. This also included the installation of a 300-gallon fuel tank which supplied enough fuel for three days operation.

All the feeders in the plant were divided into three electrical zones with the phases for each zone balanced within 10 amperes each. The generators were also divided into three electrical zones. In the main section of the plant, generators 3, 4, and 5 constituted Zone No. 1, generators 1 and 2 constituted Zone No. 2, and the two units in the annex constituted Zone No. 3. At the completion of the conversion of the plant to three zones, the arrangement of equipment was as follows:

Zone No. 1: Generators Nos. 3, 4, and 5; feeders nos. 1, 3, 4, and 5; maximum load 72.5kw; average or normal operating load 42.5kw.

Zone No. 2: Generators Nos. 1 and 2; feeders nos. 2, 6, and 7; maximum load 49.5kw; average or normal operating load 29.7kw.

Zone No. 3: Annex generators nos. 1 and 2; feeders nos. 8, 9, 10, 11, and 12; maximum load 43.0kw; average or normal operating load 25.8kw.

Under this new system, no difficulty was experienced in the plant as a single unit operating on each zone could easily handle the load of that section. Zone No. 1 had three generators because this zone had the maximum demand and as long as the load did not exceed 45kw, parallel operation could be accomplished with fairly satisfactory results. The three zone system of operation was continued throughout the remainder of Deep Freeze II.

A series of tests performed by the manufacturer on similar generating units disclosed that the trouble was in the saturable reactor portion of the regulator. The portion of the reactor which supplies electrical current to the control field in the exciter proved to be unsuitable for proper operation. By removal of a few laminations from the core of the reactor, it became much more stable and satisfactory for parallel operation of the generators.

Summary of Power Generation

Two generators were used at all times during Deep Freeze I due to the use of No. 4 AWG RH as ties between the generator and bus; No. 4 AWG RH carries 85 amps while No. 2 AWG RH carries 115 amps.

Distribution

The switch gear, consisting of seven 100-amp and one 60-amp fused safety switches, is tied to the bus bar with No. 4 AWG RH wire. Mineral-insulated, four-conductor No. 6 AWG is used for feeder mains, except to the latrine, garage, and radio. They were buried in a trench 1 foot deep and ran from the powerhouse through the tunnel to the respective buildings. To the latrine and the garage, two feeders, each three- and four-conductor No. 4 AWG, are used. The radio feeder having two runs of four-conductor No. 5 MI paralleled can carry 140 amps. All other feeders can carry 70 amps. Due to insufficient meters an accurate power

consumption log was not maintained. But by using a clamp-on ammeter and taking hourly readings we were able to maintain a record for our own use. From these readings we can approximate the use of 230 amps per hour on the three phases during the winter months. Due to the use of much single phase equipment the three phases were unbalanced but by arranging the circuit we were able to keep the difference between the high and low phase on the bus at less than 15 amps. Deep Freeze I power distribution was adequate and satisfactory.

There were nine main power feeders at Little America at the start of construction of Deep Freeze II. The switch gear consisted of eight 100-amp power panels, one 200-amp panel, and three 60-amp panels. A secondary main was spliced into feeder no. 6 in order to supply the administration buildings with light and power. Sick bay was disconnected from feeder no. 6 and placed on a new one brought out of the plant which was run on the overhead of the main tunnel. This was a four-conductor no. 6 mineral-insulated cable, and the order in which it left the power plant was designated as feeder no. 2. This provided sick bay with an isolated feeder which, in the event of any emergency, would supply it constantly with electrical power.

A second feeder (MI No. 6) was brought out of the power plant and terminated at junction box on the overhead of the main tunnel. Designated as feeder no. 8, it supplied the BOQ and the IGY ionosphere building. A third feeder, which paralleled the two existing feeders, supplied the communications building. These three feeders were designated numbers 1-4-5, respectively. At the communication building an additional secondary feeder was installed. This feeder was approximately 400 feet long and was spliced into feeders 4 and 5 and supplied the IGY geomagnetic building.

All new feeders were installed on the main tunnel overhead due to the ease of installation and maintenance. At the completion of construction of the distribution system there were a total of 12 main feeders. These feeders supplied the base as follows:

Feeder No. 1 - Buildings 2A and 2B

Feeder No. 2 - Buildings 11, 11A, 11B, 11C

Feeder No. 3 - Buildings 8, 8A, 8B, 10

Feeder No. 4 - Buildings 2, 2A, 2B, 2C, 2D, 4A, 6A

Feeder No. 5 - Buildings 2, 2A, 2B, 2C, 2D, 4A, 6A

Feeder No. 6 - Buildings 1, 3, 3A, 5, 5A, 7, 7A, 9, 9A, 9B, 9C, 13

Feeder No. 7 - Buildings 13A, 13B, 15, 12, 14

Feeder No. 8 - Buildings 16A, 16B, 18

Feeder No. 9 - Buildings 20, 23, 23A, 23B, 23C, 23D, 23E

Feeder No. 10 - Buildings 20, 23, 23A, 23B, 23C, 23D, 23E

Feeder No. 11 - Buildings 17, 17A, 17B

Feeder No. 12 - Buildings 17, 17A, 17B

With the addition of the galley, the chapel, and other units to the same zone as the communications installation, the paralleling of two generators was necessary during peak periods. The outages due to power failures were very small (less than a half hour during weather broadcasts) even though the electricians were faced with difficult equipment problems. Voltage variations were considerable at times (198 to 210), but no serious effects were noted.

Kiel Field (Little America)

Until 14 April 1956, the power supply at Kiel Field was two PU-92 5kw gasoline generators. One generator was used for lights, the operation of hand tools, and the coffee mess. The other was used for working on GCA equipment. On 2 April, the first 30kw diesel generator was moved into the generator tunnel and permanent wiring completed by 14 April. The second 30kw was moved to the field in late May. One 5kw was retained at the field during the winter night as an auxiliary power source. The generator watch and routine maintenance checks on the 30kw's were accomplished by the aviation personnel. The two 30kw's furnished adequate power for the field. However, in order to start the 50-hp frequency converter, both generators had to be on the line and perfectly paralleled. All other equipment had to be turned off prior to starting the converter. Even then it pulled the line voltage down badly for 12 to 15 seconds. Once it started, everything ran off of one generator. DC power was supplied from two 28-V, 115-amp motor generators and, after 15 November, by a large selenium rectifier.

Byrd

Generation

For base power, two D-315 30kw single phase generator sets were installed and energize three circuits. Individual generator peak load is 156 amperes. This amount was sufficient for all power requirements of the station, and only one generator was needed at a time. At no time was peak load approached, normal load being approximately 65 amperes. Some scientific equipment was affected by voltage fluctuations. The generators were wired for either parallel or independent operation, but normally were run single. Generators were rotated every ten days for maintenance checks. Prior to being put back on the line the generator was given a complete P.M. check. During the period 1 January to 9 November only two power failures occurred, both lasting about 20 minutes.

The diesel-electric sets performed extremely well during the year with the following exceptions:

1. The American-Bosch generating system failed and could not be repaired.

2. The Woodward governor was erratic in its controlling action of the diesel engine.

The exhaust gases from both generators were ducted through a snow melter producing water for the head.

Distribution

All distribution panels are the 60-ampere multibreaker type, and have proven satisfactory. Breaker "A" in the powerhouse at the main panel and Breaker "B" in the head are 100 amp. All outside wiring is eight-conductor no. 3 mineral-insulated cable, which is very easy to handle. The circuits are:

Circuit No. 1 - To building 2 (radio), and building 1 (mess hall)

Circuit No. 2 - To building 2 (met), and buildings 7 and 8 (geomagnetic)

Circuit No. 3 - To building 6, building 10 (inflation shelter), and building 14

All outside circuits were buried to a depth of approximately 2 feet. Circuit No. 2 was broken by the D8 blading for the fuel cache, and a junction box was installed midway between buildings 2 and 7. One hour was lost due to power failures, each of 30 minutes' duration. One was due to the generator overheating, and the other due to a break in circuit no. 2. All inside wiring was 12-3 romex for lights and receptacles, with the exception of using 12-3 BX (armored cable) for wiring Jet heaters. The wiring of individual buildings was in accordance with BuDocks plans.

South Pole

Generation

The two 30kw generators installed in the powerhouse from Deep Freeze I were run alternately for electric power. A third unit, delivered for Deep Freeze II and never run, was located near the mess hall as an emergency spare. In addition, one 4kw generator was installed in the barracks building as an emergency lighting plant. Because of the altitude (9200 feet) the power output of the generator engines was only about two-thirds normal output. For much of the year one generator was able to carry the full base load. However, late in the year the generator output dropped somewhat and one would no longer carry the maximum base load. Consequently, certain operations were curtailed, and the clothes drier was secured. Superchargers ordered and procured for Deep Freeze III should materially improve engine performance, which, coupled with engine overhaul, should again make it possible for one generator to carry the full base load. Average power consumption was about 18kw and the maximum near 24kw.

Both generators used an excessive amount of oil — 10 or more quarts per day. The addition of Mystery Oil did not help to rectify this situation. As no spare parts such as head gaskets were available, no major maintenance work was possible. Parts for the complete overhaul of both engines were ordered for Deep Freeze III. Some trouble was experienced with engines overheating due to externally clogged radiators. Sawdust, lint, and general debris from the garage necessitated removing the radiators periodically to flush out the foreign material. Regular preventive maintenance was performed every 240 hours. Fuel consumption averaged about 1.9 gallons per hour. During the construction period, with a 100-amp load as maximum, the units used but 20 to 25 gallons of diesel fuel per day. Individually each unit is reliable and effective. The D-315 engine has proved itself reliable. The primary difficulty with these sets is that they are extremely difficult to parallel.

The Hercules 4kw generator was used during the early stage of the construction period for power, communications, and several small portable power tools. Only one TBW could be operated at a time. The generator did not perform satisfactorily

for prolonged service, so the 30kw units had to be installed sooner than planned. Considerable trouble was caused by surging and by "gumming up." Perhaps the surging was due to air starvation, as opening the generator shack appeared to help where all other remedies did not. The gumming up was believed to be caused by a poor grade of gasoline. Engine repairs were not possible due to lack of spare parts. Therefore, the generator was rigged to an engine salvaged from one of the 28-volt Waukashas and the unit installed in the barracks building for emergency power.

The 28-volt Homelite APU unit was used to provide power to the permanently installed AN/GRC-9 and VHF ARC/1 transceivers, both of which were required for air to ground communications, and for communications with Beardmore Camp. The unit proved reliable in all respects; it was quick-starting and dependable. After the Waukashas were damaged, this unit served as a standby in case aircraft required it.

Two 28-volt Waukasha APU's (sled-mounted) were delivered by airdrop and were damaged beyond repair. The units could be stripped for spares and were set aside for this purpose. They were intended to provide emergency power for aircraft on the ground.

Distribution

Initially communications was on a separate circuit, based on experience at McMurdo which reduced interference, and allowed maintenance on other circuits without interfering with radio operations. If the total base load exceeds the 30kw output of one generator and the generators are not able to be paralleled, it might be necessary to break down the circuits so that portions can be run on each generator. This is not desirable, however, as it will cause excessive consumption of fuel and wear on the generators.

Power distribution during Deep Freeze II was as follows:

Circuit No. 1 - Head, radio, garage, barracks (both), tunnel lighting

Circuit No. 2 - Drill press, mess hall, weather bureau

Circuit No. 3 - Science building, inflation shelter, astronomy, geomagnetic tunnel, ionosphere recorder

Interior wiring for the most part was Romex. This type of wiring is very satisfactory inside. Mineral insulated cable was used for exterior wiring and was strung overhead in the tunnels. It is far superior to Romex and rubber covered wire

for outside use. Cotton covered wire is excellent for portable and extension use outside at the extreme low temperatures encountered (-100 F). Bare galvanized baling wire, spaced about 4 inches apart, was used for a temporary lighting system in the snow mine. This was later replaced with wire supplied by IGY. Lighting fixtures and hardware in some instances were in short supply. Empty coffee cans were used as junction boxes for switches, outlets, and for mounting goose neck lighting fixtures.

Basically, the electrical distribution system of the station was well designed. However, the supply of material, hardware, wire, and tools was far below station requirements. Grounding is a definite problem on the Plateau. The only solution to the problem to prevent arcing from two conductors of dissimilar potential is to make everything as nearly equal in potential as possible. In order to accomplish this, every piece of metal in a building was bonded together using the aluminum lining and clips, or copper wire. This resulted in a building of singular potential for all practical purposes. The building was then tied into the MI cable covering (copper) which effectively made all buildings the same potential. Arcing is a definite problem in the inflation shelter where expolsive hydrogen gas is used. Also, the dry air is conducive to causing large buildups of static electricity, especially in conductors such as the antennae. A coil-type bleed-off system designed at McMurdo, which readily passes dc currents but resists the passage of ac currents, might be installed at the Pole Station if the antennae static charges become too much of a problem.

Lighting

There were many varieties of lights for the station and in general lighting was quite adequate. The overhead lights in the Clements buildings were supplied with 100-watt bulbs and provided the major source of illumination. The few fluorescent lights available were, however, far more satisfactory and efficient. The next most important lighting facility so far as eyestrain is concerned is the bunk light, since considerable reading is done after work hours. The bunk lights sent down with Deep Freeze II are wholly inadequate. The principle of the goose-neck lamp is excellent, but with this particular model the neck became flaccid and limp after one or two weeks.

For outside lighting, the most important factor is the use of cotton braid insulated wire which will not stiffen in the extreme cold. Any rubber insulation becomes brittle and tends to crack. For personnel use outside, the head lamp with separate battery pack is strongly recommended. The battery pack may be kept under one's parka where the batteries will not freeze, and the head lamp frees both hands for jobs which are naturally more difficult because of cumbersome gloves and clothing.

Recommendations

1. If any significant increase in electrical load is contemplated, larger generators will in all probability be required.

2. An adequate spare parts, wire, hardware and special tool, inventory should be provided to permit major engine maintenance and overhaul work. These items were ordered for Deep Freeze III. A 50- to 100-percent increase in wire, hardware, and tools should be allowed.

3. An overhead fuel tank of sufficient capacity should be constructed to serve both generators to obviate the necessity of twice-daily fueling. (This will probably be done by Deep Freeze III personnel.)

4. Personnel should be acquainted as much as possible with the generator sets at the station, as well as with motors of all types, and care and maintenance of NI-CAD batteries. School or refresher courses in these fields would be an excellent investment.

5. Fluorescent lighting should be used throughout the work areas of these stations. They draw far less power and certainly give a brighter, more uniform light.

Hallett

Generation

The electric power generating units for this station are three model D-315 30kw diesel-driven generators. These units were considered adequate and were run alternately. Two generators were located in the powerhouse (Building 4), and the third in the auxiliary power building (Building 11). These generators operated satisfactorily with very little servicing required other than routine maintenance. No special problems were encountered. The exhaust of the powerhouse generators was used as a heat source for the snow melter. The alarm system of the main generators was connected to the master fire alarm system to guard against station power failures. Failures normally were caused by overheating. With the alarm system operating, sufficient time was allowed to prevent power failures. This station sustained only four short power failures through the wintering period.

A portable generator (5kw) was towed to a suitable location to furnish emergency power for the communication facilities and homing beacon. It operated very satisfactorily, requiring only routine maintenance.

Lighting was adequate at the beginning of the operation. During the winter the supply of 100- and 200-watt light bulbs became scarce. By the end of winter only 50 watts were available.

Wilkes

Generation

A major modification in the distribution system was made early in the year and this simplified the operation of the electrical plant considerably. The entire base was split into two separate circuits with one containing the scientific equipment and the other containing the intermittent heavy loads such as the refrigerators and the arc welder. This eliminated the problem of paralleling the generators and kept the frequency on which the scientific equipment was operating fairly stable. One 30kw generator was operated continuously on each circuit and each could handle peak loads without operating over capacity. The current and voltage regulators could not be made to operate properly in the diesel engine electrical system and these systems were disconnected. In order to keep the generators from overheating, ports had to be cut in the panels in front of the radiators. When these were enclosed with a housing on the outside of the building and open at the top, they remained clear during storms. They also provided excellent excape hatches.

Distribution

The electrical installation operated well requiring for the most part only routine maintenance. Total power outage during the year was under two hours, and most of that was due to human error rather than equipment failure. Some difficulties were encountered with the distribution network but none were of a serious nature. A small fire was started in the powerhouse due to a short circuit in the fire alarm system. It was caused by a wire which had been damaged when drawn into a length of conduit. The mineral insulated cable used for distribution in the station gave no trouble but was hard to work with due to the lack of the proper special tools. It was successfully spliced when broken once by a tractor rooting around in the wrong place. Romex cable and rubber covered cable were installed as distribution wiring for some outlying buildings, and this became chaffed rather badly by action of the wind. No breaks or shorts resulted as the wires were checked periodically. Some type of metal protected cable should be used for this type of wiring.

Lighting fixtures were fairly adequate, but the addition of some style of lamp for drawing table work and some floor lamps would have been valuable. A synchronous electric clock for use in checking the station power frequency would allow very close control of the generated frequency.

Miscellaneous Equipment

The 10kw Hobart gasoline-driven generator operated well during its use in the Penguin and Skua egg-temperature telemeter studies. Only failures were a leaking gas pump and a defective reed type power frequency meter.

The 5kw Katolite gasoline engine generator used at the icecap station required considerable maintenance and repair, but this was somewhat due to mistakes made in caring for it and the fact that it was installed in too small an operating space for adequate cooling. This, too, was an application for which the equipment had not been designed.

Ellsworth

Generation

The powerhouse (Building 7) was completed in the later stages of construction and the first power from the permanent installation was provided to the communication building on 10 February 1957. The crates in which the 30kw generators were packed were clearly marked "combat loaded." Upon unloading it was found that four of the seven had been stored on their sides in the ship. Fortunately, no permanent damage to these resulted. The diesel engines for generators should be combat loaded and stored accordingly. After checking, all seven generators were placed in operation without difficulty and performed satisfactorily. Five generators are located in the powerhouse and two in the garage (Building 6). The five in the powerhouse were all on the line and more than sufficient to carry the load.

Distribution

The electrical distribution system used MI cable run in the tunnels. When this cable was being run a high wind was blowing with a heavy fall of wet snow. Making splices in the cable was very time-consuming. The ends of the cable showed a tendency to absorb moisture and lower the resistance to ground. This was overcome by drying out cable ends with heat. If split bolt connectors had been available with the cable for making splices the installation would have been much easier and faster.

Miscellaneous Equipment

Ignition and spark plug trouble was experienced with the 10kw gasoline-driven portable generator. A small diesel-driven generator would be preferable to the gasoline-driven one.

Lighting

The lighting of working and living spaces was good. However, an insufficient number of 75- and 100-watt bulbs were included in the supplies. The use of fluorescent lamps should be investigated. It is believed they would provide better lighting in working spaces and would draw less current. Red-coated light bulbs should be included in electrical supplies to light the passage ways in buildings at night.

WATER SUPPLY

McMurdo

Procurement

On the hills of Cape Armitage, a mile east and south of Hut Point, water from melted snow collected in pools varying from 10 to 100 feet in diameter. From these pools, water was procured for camp use during the construction phase. This water was clear and palatable, of medium hardness, and free from human contamination. However, skua gulls bathed in the ponds. Plant growth in the ponds appeared to be restricted to leafy algae. Water was collected twice daily and carried to the camp in 25-gallon galvanized cans on weasel-drawn sleds. After opening the permanent mess hall, water from the melting of snow obtained from the hills behind the camp was used. Usage of water during the winter of 1956 was approximately 15 gallons per day per man. During peak summer periods, snow was gathered on a 24-hour basis. No facilities for the chlorination or filtration of water were present.

The snow fields used were principally behind the powerhouse on the windward side of camp. A snow fence was erected in this area which caught a great deal of snow and reduced travel time for the equipment. D4 tractors or Pettibone Carylifts with scoops were used to bring the snow to the melters. During the summer this field became depleted so an alternate field at the base of Fortress Rocks was used. This snow field has the disadvantage of being too far from camp for easy access. The amount of snow available for water may soon prove to be a problem, since the snow melted or used during 1956-1957 summer operation was not replaced during the 1957 winter period. Several fairly sizeable freshwater lakes were located within or quite near the camp. These could provide an emergency source of wash water during the summer. However, without treatment and testing it should not be used as a source of potable water.

"Several major changes were made to the water supply system as designed for the operation. All water was to be melted in snow melters located in the powerhouse and transported throughout the base by a water carrier. However, the water carrier proved to be too fragile to be pulled over the earth streets of the camp. Therefore, the water carrier was installed permanently outside the galley and all water consumed by the galley is made in it."[5]

The other melter, in the powerhouse, operated with the heat exhausts from the electrical generators. This melter provided water for showers and laundry facilities as well as for the galley, latrine, and photo lab during the peak periods or breakdown or repair of the galley melter. Normally the galley melter provided water for the galley, the latrines, and the photo lab. An emergency snow melter was installed in the power plant. This melter was fabricated from a tar melter. It was eventually removed to make space for the third electrical generator. Tests indicated that it would produce approximately 70 gallons of water for each gallon of fuel burned. This unit proved valuable later to provide fresh water at the runway for flooding areas damaged during air operations.

The water obtained was soft and palatable. The snow, however, contained considerable volcanic ash, which occasionally imparted slight turbidity to the water but had no noticeable effect upon personnel drinking it. During summer months, the danger of contamination of snow-collection areas was greatly increased by the large numbers of personnel in the camp. Though no difficulty traceable to contaminated water was experienced, the possibility of trouble was present and filtration and chlorination of water would be desirable. Purification of water is important, but secondary in importance. The water had a slight fuel taste, which was alleviated by icing the water before usage. Chlorination has not been done as of Deep Freeze II and is probably unnecessary in winter, but should be performed upon the water during the summer. Bacterial counts were not done because of lack of culture facilities.

"The soot turns to a dirty mud-like deposit in tanks. The water was not injurious to health but not very desirable when seen in food or for washing. A great portion of dirt in water in clothes washing machines was removed by filtering water through cheese cloth. This, however, is a slow process and could not be used for other purposes."[18]

"Assume that clean snow is not available within reasonable distance of camp. Suggest trying lube or fuel oil filters where pressure is available. Purolator filter with P-40 cartridge successfully filtered one GPM at 3 PSI, two GPM at 9 PSI."[28]

Two processes were used to melt the snow during Deep Freeze II. The most economical, but the slowest, was the system located in the powerhouse. There snow was dumped into a large collection tank through which ran the exhaust pipes from the engines of the generators. The other method was by the 750-gallon tar pot in the galley annex. Two diesel burners heated and melted the snow. This system was the fastest and most convenient method. Normal time for melting enough snow to supply the camp by both methods was six to eight hours a day, three times a week during the winter, and about 10 hours every day during the summer.

A measured cubic foot of snow would yield almost exactly 3 gallons of water. However, the 72-cubic-foot bucket used on the Carylift would yield only about 180 gallons, or 2.5 gallons of water per cubic foot of snow. This was attributed to voids created in gathering up the snow.

Permanent piping delivered water from the powerhouse melter to the showers and washing machines. Likewise, permenent piping supplied the galley. Rubber hose was laid down each time it was necessary to refill storage tanks in the heads and the photo lab. This method was satisfactory as long as the hose was stored in a warm place. Water was pumped at 20 gpm or more, and the hose was taken up and drained as soon as pumping was completed. Runs of over 100 feet have been used in this manner in the coldest weather using 3/4-inch hose. One and one-fourth-inch hose was used to drain water from the powerhouse storage tanks to the galley in the same manner during milder weather, a distance of over 300 feet (at 30 psi). The only water that had to be hauled in camp was wash water for the heads and sick bay.

In the powerhouse, there are five 975-gallon galvanized tanks, two are used for settling and three for storage. These five tanks constitute a reserve supply in case of melter breakdown. In addition, an overhead tank of 575-gallon capacity serves the laundry and shower facilities. The galley melter can hold 1000 gallons. In addition, two overhead storage tanks of 150-gallon capacity each served the galley. Each latrine is provided with an overhead 375-gallon tank. Gravity flow is used from all overhead tanks except in the powerhouse where approximately 20 psi of air is used to improve the rate of flow to the laundry and shower. Thirty-gpm electrical pumps are used to transfer water from melters to storage tanks and overhead tanks.

During Deep Freeze II, two 1000-gallon tanks were installed in the snow melter room aft of the galley. With the heater set at 208 F, continuous hot water was available. Hand-carrying of water to the sick bay, in 5-gallon cans, was eliminated by the installation of a 150-gallon storage tank. Water was delivered by rubber hose from the galley. A small 2-gallon-capacity hot-water heater was provided. The total water storage capacity was 10,400 gallons.

Consumption

Total water consumption for the camp during Deep Freeze I varied between 10 and 18 gallons per man per day. The average was about 14. During the heaviest population, total consumption ran about 4700 gallons per day. Of this, about 2600 gallons went to laundry and showers, and about 350 gallons were necessary to support the photo lab. The galley required 650 gallons. The balance was divided between the three heads. No definite usage curve can be drawn up as usage varies a great deal with type and amount of work being done, the weather, and the number of personnel in camp. Water hours for laundry and showers reduce consumption during periods of peak population. A safe planning figure for bases of this type would be 20 gmd.

Problem Areas

Snow Sources. It may seem strange that a source of snow should constitute a problem in the antarctic. Yet, at McMurdo Sound, this is actually the case during the summer season. During the winter, the rough, rocky terrain becomes covered with snow but with the first rays of sunlight, it begins to disappear. The black rocks absorb large amounts of heat which starts the melting. Long before the summer is over, the site is virtually bare of snow. At the camp only the hard ice fields, one in the valley between the camp and Hut Point, and one behind the powerhouse remain. To obtain snow, it becomes necessary to go to the base of the mountains ringing the camp site. The best and most available supply was found at the foot of "Fortress Rocks." Here the snow was drifted 20 to 30 feet deep. The primary limitation here was that of distance and terrain. It was necessary to drive the Carylift 2000 feet each direction over a steep rocky road.

Pollution. During the summer season McMurdo is a bustling little community of almost 400 people. During the normal working hours, dozens of additional people pour through the area, coming from the ships and the nearby New Zealand camp. They swarm the vicinity and environs of the camp. The result, as usual where human beings congregate, is a danger of pollution of water sources. This is particularly true in such a forward area where inhibitions are relaxed and personal habits are changed. Snow recovery areas were flagged and made "out of bounds." Special care had to be taken to enforce this. It was also necessary to closely examine drainage slopes to prevent pollution being washed into the snow areas. Equipment used for snow recovery had to be closely watched and not used for other purposes.

Another source of pollution was the constantly blowing dust and dirt which filled the air. This could not be combatted without filters. Some sediment was removed from the water through settling out in storage tanks. However, all water usually contained some sediment.

Recommendations

1. That chlorination, filtration, and testing equipment be furnished.

2. That a study be made to determine the feasibility of providing evaporators to make possible use of sea water.

Little America

Water was provided by snow melters. Snow was brought in on 20-ton sleds from the snow "mine" located one-half mile from the base. The sleds were spotted at the snow melters, and the melters were kept filled by men standing the fire watch. There are three snow melters, one in the powerhouse, one in head No. 1, and one in the galley. The powerhouse melter had a 1000-gallon capacity and utilized heat from the generator exhaust. Water was stored in two 975-gallon tanks in the powerhouse and pumped through a 1-inch line at 20 gpm to a 300-gallon storage tank in the head in Building 13. The 300-gallon tank was elevated to a height of 12 feet on a 2-inch pipestand and the water was gravity-fed to the fixtures. Water consumption at this location was approximately 1200 gallons per 24 hours during the period of isolation.

The galley snow melter utilized hot water circulating through four 1-inch pipe coils, and has a capacity of 187 gallons. A 300-gallon storage tank is elevated to a height of 12 feet on a pipestand and the water is gravity-fed to the fixtures. Water was consumed at the rate of 700 gallons each 24 hours during the period of isolation. The snow melter in head No. 1 is the same as the galley snow melter, and the water consumption here was 400 gallons per 24 hours.

The total amount of water used per day was 2300 gallons, or approximately 30 gallons per day per man. It was further determined that 1 cubic foot of packed snow weighing 26-1/2 pounds would produce 3 gallons of water. Water was adequate in amount, except for the fact that drinking water was not available in the barracks or working spaces. The water contained much particulate matter, mainly carbon particles from the many chimneys at the base, and also some scale from the snow melters. There was no means of testing water bacteriologically, but no cases of diarrhea or other water-borne infections occurred. It is felt that further treatment of water produced by snow melters at Little America V is unnecessary except to improve the taste.

The water-supply system during Deep Freeze II was changed very little from the original layout of Deep Freeze I. Suggestions of Deep Freeze I were followed and filters were provided. A diatomaceous-earth filter of 2 square feet capacity

was installed in the galley water plant between the melter and the storage tank. Allowed to run continuously, the filter required cleaning every two and one-half to three hours and removed a great amount of foreign matter from the water. A black scum was found to adhere to the filter bag, and it was determined to be a result of soot blown on the parked snow sleds from stove pipes distributed throughout camp. With the existing building layout, it is extremely doubtful whether a location can be found around camp where some soot will not be deposited in a days time. In September 1957, the site of the snow mine was moved from a position one-half mile southwest of camp to a spot one-half mile southeast of camp. This was done to insure a minimum of contamination by soot and debris wind-carried from camp. Since the prevailing wind direction is southeast, this solution proved the best.

Two other types of filters were included in the Deep Freeze II allowance. One, manufactured by CUNO, was a cartridge-type fibrous insert which was installed directly in the water line. It removed most large particles from the water. However, the reserve supply of cartridges was not found until the final dig-out in the spring. The second, a diatomaceous-earth type manufactured by INFILCO, was not installed as it required a pressure water system.

At intervals during the year all snow-melter tanks were drained, hand scrubbed, disinfected, and flushed. A variety of foreign matter was found, including flashlights, shovels, eyeglasses, rust (from sleds), wood chips (from sled stakes), and a mud-like substance thought to be a result of soot deposits on snow sleds. Water at 200 F was diverted through galley cold water pipes on a weekly basis. Green-soap cleansing of the drinking dispenser in the mess hall was supervised daily. Repeated water analyses revealed 24-hour counts of 10-milliliter samples from galley snow-melter tank and blow-torched sink spigots to be innumerable. All that can be said in defense of the potable water system is that it represented a good compromise under rigorous field conditions.

On 17 May 1957, samples of water were obtained from galley faucets and water dispenser spigot by the medical officer. These were cultured in peptone beef broth tubes. At 24 hours there was florid growth, and nutrient agar streak plates were subcultured. A mixture of non-motile gram-negative feculent colonies resulted, some grossly similar to _E. coli_ in colony characteristics. These were grown in sucrose and dextrose fermentation tubes (lactose was not available). Differential tests for _A. aerogenes_ were not done. One strain did not ferment sucrose and dextrose, another did. It was felt that these organisms were probably _Alcaligenes fecalis_ and _E. coli_. Personnel contamination of the water supply was responsible by hand contact of spigots and water containers, and by other articles contacting the melter tanks. It is felt that some other form of potable water production is needed.

Open tanks are not acceptable for long periods of time or for large numbers of personnel. A complete wanigan unit for snow melting with built-in hypochlorinator would seem desirable. However, some agent other than hypochlorite should be used because the low temperatures interfere with its action. The problem of distribution would be difficult but probably not insurmountable.

During the course of Deep Freeze II, total water consumption at Little America V remained high for several reasons:

1. The addition of two new photo labs (hobby shop and IGY).

2. The increase in base wintering-over population from 73 to 109 personnel.

3. The addition of head facilities in the officers quarters, building 16.

4. The inclusion of a fully automatic washing machine in the officers head.

However, average daily consumption was computed as 30 gallons per man per day, the same as for Deep Freeze I.

Byrd

Two 180-gallon snow melters were installed, one in the mess hall and one in the garage/powerhouse. The latter was operated on exhaust heat from the generator engines. The water was pumped to an elevated 975-gallon storage tank in the latrine.

The water system constructed by the MCB (Special) Detachment One proved satisfactory for Deep Freeze II, except for the following points:

1. Soot from the galley and generator stack contaminated the snow melter and imparted a diesel smell and a trace of oil to the water. No filters were available for installation in the system and efforts to remove this deposit by flushing domestic detergent soap powder through the system were only temporarily effective.

2. The over-enthusiastic shoveling of snow into the snow melter, and certain storm conditions, caused overflow onto the powerhouse deck. A float gauge readable on the outside by the filling hatch and in the powerhouse would overcome this problem.

3. Relocation of the electric pump switch from the powerhouse to the head would eliminate overflow waste when the storage tank in the head is being filled.

South Pole

During the initial construction period, prior to the erection of the powerhouse and its melters, all water was made in GI cans using two immersion type heaters (BY&D NR Heater Field C66-H-365-325). Periodically a crew would take a vehicle and sleds to the snow field north of camp to bring in snow blocks. A cache of blocks was stored adjacent to the melters and covered with a parachute to keep blowing dirt from the camp from contaminating it. The GI cans of water were stored in a Jamesway at night to prevent freezing. Each morning, night watch carried the cans to the heater site and inserted and lighted the heaters so that when the cooks were called, hot water would be ready by breakfast. This water was used for drinking, bathing, and washing dishes. After 15 December 1956, water for washing, laundry, and showers was obtained from the melters in the powerhouse. The immersion heaters were still used for the galley, as the majority of the water made in the powerhouse was used to fill storage tanks, or was pumped to the latrine for showers, laundry, and the lavatory. Use of the immersion heaters was discontinued as soon as the galley tanks were completed.

Water will be a problem only as far as gathering snow is concerned. A 10-foot wide tunnel was provided on the grid west side of the powerhouse so that a weasel can pull loaded sleds through the tunnel to facilitate putting snow in the melter. Prior to the departure of the construction party, an ingenious system of gathering snow in parachute bags was developed which increased the amount of snow transported in any given time tremendously. The parachute bags can be shoveled full, hold approximately 10 cubic feet per bag, and are easy to handle. During Deep Freeze II, the two 1-ton sleds were used to haul snow. The sleds were fitted with plywood sides and bottom.

The snow mine was begun on 1 April when outside temperatures (-50 to -60 F) precluded the use of vehicles for hauling snow. The mine itself went down on about an 18-degree slope and averaged about 50 square feet in cross section. The downward slope was maintained to concurrently provide the glaciology deep pit, and by 1 December 1957 had reached a depth of 90 feet. No shoring was required. Electric lights were strung in the mine for illumination. The filled parachute bags were hauled up, three at a time, on a 200-pound man-hauling sled pulled by a jury-rigged winch. One-quarter-inch nylon climbing rope was used. A regular electric winch was ordered for Deep Freeze III, but was not received.

The advantages of this system were the easy access from the mine to the melter, the purity of the snow, the relative warmth of the mine (-55 F), and the greater density of the snow. There were two main disadvantages. First, below 30 feet the snow became so dense that it was impossible to use the ice saws, and more work was

required to bring up the same amount of snow. A Swiss axe with a spoon-shaped blade worked very well. The chipped snow was then shovelled into parachute bags. Second, after several months of digging, the lint and fibers from the clothing of the diggers began to be appreciable in the loose snow of the floor of the mine. Snow brought to the surface could be stored indefinitely in block form near the hatch of the snow melter. This system appears sanitary, the blocks being handled by gloved hands only three times from mine to melter. The system required approximately two hours per man per week on the snow detail. It was entirely satisfactory and can be continued indefinitely in the future; the snow at mining depths being far from surface contamination.

The snow melter, which operated from the hot exhaust of the diesel generators, had sufficient capacity to meet the requirements for eighteen men. It does not, however, melt fast enough to provide adequate water for many men over 18 or 20; and should the base complement be increased a larger melter would be required. The present melter has a 240-gallon capacity and takes about four hours to make 100 gallons of water. The water is then pumped to the 940-gallon main storage tank adjacent to the melter and then to the 180-gallon head water tanks thru a 3/4-inch garden-type hose. A 1-inch pipe was run from the main tank, through the tunnel and the barracks building, and on into the 225-gallon galley tank. It was drained immediately after each pumping. Despite the low tunnel temperatures and the length of the unprotected tunnel runs, the line only froze once. The head and galley tanks are elevated, and water is gravity fed to the petro hot-water heaters and to the sinks.

It was found that dust from the garage workshop settled on top of the water in the melter so that it became necessary to cover the melter with a hood of parachute material. The water was also made less clean by the inclusion of the clothing fibers deposited in the snow mine.

The surface snow is very light, about 0.30 gms/cc in its natural state. It does not make a great deal of water. One cubic foot of snow makes approximately 2 gallons of water. The total water consumption was 11 gpd/man in 1956 and 13 gpd/man in 1957. The entire base consumption of 200 gallons per day resulted from galley use of 79 gallons and about 121 gallons in the head.

The snow melter installed in the powerhouse was not fabricated as ruggedly as desired. It had several leaks which could not be found and which drained into the exhaust causing a very vaporous exhaust. It had no drain valve at its lowest point so that water getting into the pipes during periods of nonuse could not be drained off prior to lighting off the generator. A drain valve was brazed into the system on the melter at the Pole. Many of the pipe fittings were makeshift, brazed on the job due to the loss of many fittings during delivery. Most water piping is galvanized iron, but copper is also used. All storage tanks are galvanized steel.

Recommendations

1. A filter system should be made available to eliminate unavoidable contamination. The present pumping system is inadequate to handle the extra load of a filter and will require replacement.

2. A winch capable of pulling 1000 pounds with 1000 feet of cable should be provided for the snow mine. An electric chain saw, with a 2-foot blade should also be provided.

3. A larger snow melter should be provided if the complement is to exceed 20. Consideration must be given to influx of summer personnel, which created serious water problems summer 1957-58.

Hallett

The determination of a reliable source of water for the station presented several difficulties. First, the absence of any continued snow cover and the contamination by penguin wastes eliminated snow as a source of water. Second, it was believed that even during the winter period there would not be any appreciable snow cover at the station site. A large glacier existed on the slopes of Cape Hallett approximately 1 mile by trail from the station. During periods when the temperature was above 30 F, melt water from this glacier was collected in a catch basin and piped down the slopes to a 1000-gallon water tank mounted on an Athey wagon. This tank was then hauled to the station and the water pumped into the various water storage tanks located inside the buildings. This source of water was variable and unreliable in that it was dependent upon the air temperature. As in the case of the snow, it was believed that this would not provide a source of water during the winter period.

Two evaporators, with a rated capacity of 85 gallons per hour, were installed at the station. The evaporators had limitations; however, during the construction period they proved to be the most reliable source of water. The limitations of the evaporators were primarily mechanical. They were not suitably equipped for operation in the antarctic area. The extreme low temperature of the intake water (30 F plus) reduced the efficiency of the units to approximately 50 percent. It is suggested that a preheater be installed on the intake line of sufficient capacity to raise the temperature of the intake water to a minimum of 70 F. It is to be noted that these units were received at the Cape Adare station marked "combat packed;" however, neither unit was equipped with intake nor discharge hoses, nor were foot valves and strainers for the sea end of the intake lines provided. These items were

improvised from available materials, and both units successfully operated approximately 20 hours. During this period water consumption for all purposes averaged approximately 400 gallons per day for a station population of 46 men, or about 8 gallons per day per man. All water used was chlorinated in accordance with instructions provided by the station medical officer.

Since a source of water appeared to be one of the major problems confronting the wintering over party, the problem was thoroughly investigated and evaluated. Each building requiring water had been provided with a snow melter. But since it appeared that snow would not be available in any quantity, these were of no great value as a source of water. Even when primed with water covering the heating element, they were not an effective melter for glacial ice. The designed water storage capacity of the camp was approximately 1600 gallons with an additional 1400-gallon potential from the spare 1000-gallon tank mounted on the Athey wagon and a 400-gallon water trailer. This gave a potential 3000-gallon storage or a 30-day minimum water supply for the wintering over party, but no reliable means of resupplying. Since excess building materials were available it was decided to construct an additional building to serve as a water production and storage building. The building housed additional water storage tanks and the two evaporators. A covered, insulated, plywood tank was provided adjacent to the building and heated by ducts from a jet heater. This facilitated the melting of sea ice or glacial ice which, when subsequently distilled, would provide an adequate and reliable 150 gallons per hour water supply for the station.

After the development of the generator exhaust snow melter system, the original snow melter was removed, and the area converted into a dark room. Later the evaporators were removed and the rest of the building converted into a recreation room. The three Burks well-pumps provided this station were used in the water system and operated satisfactorily. In addition to these, a number of small, electric, transfer pumps (approximately 8 gpm) and hand pumps were available. No large-capacity or high-speed pumps were provided. They were recommended for Deep Freeze III, not only for water transfer, but for fire fighting. No serious problems were encountered with any pumps provided when properly used.

Wilkes

Early in the year water was pumped from a melt-water pool found in a natural basin on a rocky outcropping near the base. After 5 April 1957, snow was obtained from fresh drifts by means of a tractor with a scoop; the station water supply was provided by a 750-gallon Rosco asphalt kettle which worked very well as a snow melter. The Wisconsin engine powering the blower for the burners received hard usage and required a good deal of maintenance; but it was never out of service

long enough to cause a water shortage. The size of the kettle was just about ideal, and it provided extra water storage during much of the year since it was insulated and could be left full of water. During cold weather the water in the melter could easily be heated well above freezing point so that the hoses would not freeze as the water was pumped inside. Water was distributed from the snow melter to the inside storage tanks in the head and galley by means of rubber hoses and a small centrifugal pump removed from a vapor heater.

As installed originally the inside storage tanks were used as pressure tanks reducing by half the amount of available water in the system. The total amount of water that could be stored was about 2000 gallons including that in the snow melter and another heated outside storage tank. Four Cuno cartridge type water filters were installed, two in the head and two in the galley. They proved very satisfactory in keeping the water free of sediment. The Petro water heaters worked well requiring only routine maintenance.

Ellsworth

Snow used for making water was collected at sufficient distance from the station to insure its purity. The melting and heating apparatus were inspected weekly for cleanliness. Although both charcoal and filters were available, only the latter were used. Increased rusting and other particulate matter necessitated the replacement of filters more and more frequently until at the end of the year they had to be changed at least every week; otherwise, the water pressure would fall off. Changing these filters took only a few minutes. Samples of water were inspected regularly for clarity, odor, and freedom from foreign material.

In future operations bacteriologic media for culturing and sodium hypochlorite for chlorination should be included in supplies to test for and treat contaminated water.

SANITATION

Sanitation problems are lessened by the prevailing cold temperatures of the antarctic. However, in some respects this is a blind which could result in unanticipated dangers. There is a general tendency, predicated both on cold expectancy and the antarctic tradition of small expeditions, to pay little regard to sanitary problems. Also the absence of flies, mosquitoes, and other disease spreaders tends to lull the antarctic resident.

McMurdo

Sanitation During the Tent Camp Phase

Sanitary conditions in the mess area and galley were substandard prior to the occupation of the permanent building. This was due to the necessity of cooking and eating in tents, the low temperatures and high winds, the difficulty of procuring water, and the field ranges provided. Personnel ate from field mess kits and washed them in 25-gallon galvanized cans heated by diesel fuel fired immersion-type heaters. Because of the above factors, cleanliness of mess gear was suboptimal. Nevertheless, there was no illness in the camp at all suggestive of propagation by unsanitary food handling. With the occupation of the permanent mess hall and galley, sanitary conditions became satisfactory. Trash was hauled to an area removed from the camp and burned. Garbage was extremely small in amount. It was collected in 55-gallon drums which were allowed to freeze and then dropped into tidal cracks.

The limited amount of water and the scarcity of stoves made bathing and washing very difficult. No showers were available except on the ships, and camp personnel usually returned to the ships every two weeks for showers. Upon occupation of the buildings, washing became easier, but bathing still was not immediately possible. Pit-type latrines dug in the snow and protected by canvas wind screens served as heads in the initial phases of the operation. They were supplemented later by enclosed latrines (some heated) using cut-down 55-gallon fuel drums for collection offices. When filled, these were dropped into open tidal cracks. The latrines were adequate although uncomfortably cold if unheated.

Sanitation in the Permanent Camp

Disposal of Human Wastes. Three heads were provided for use of camp personnel. Feces are deposited directly into half drums. Urine likewise is collected into half drums. Odors were not bothersome. One head is located directly across the street from the galley snow melter. Here great care must be exercised to assure that the snow is not contaminated by the removal process. Solid human wastes accumulated at the rate of one-half barrel per day per hundred men. The receptacles were easily hauled by sled to a dump on the edge of the bay ice about 500 yards from the camp. This dump was partially covered with snow drifts as it increased in size and at no time was it aesthetically or hygienically objectionable. It is anticipated that the dump will periodically be carried to sea when the bay ice goes out. In summer, skua gulls were observed to frequent the dump area, and they constitute a potential source of fecal contamination of other areas. The non-existence of flies or other insects and of rats makes an open dump acceptable in the antarctic whereas in other places it would be prohibited.

In such a forward area, there is a strong tendency by personnel to urinate whenever and wherever the urge is felt. In such a crowded camp, where the water supply depends on the adjacent snow, this must not be tolerated. Careful education is a must because people cannot be depended upon to exercise common sense. Signs of urination in the middle of flagged snow recovery areas have been seen. All hands were continually directed to urinate and defecate only at the latrines to prevent contamination of the area, and especially of the drinking water.

Mechanical Wastes. Waste water from the galley and the heads was collected in a waste water sled of 325-gallon capacity. The water was then emptied as rapidly as possible in the dump area. The waste water sled had an insulated tank in order to reduce the rate of freezing. Usually the waste water was warm which also helped to prevent freezing. Water from the laundry and showers at the power plant was at first collected in a very large waste tank. However, material to construct a waste water disposal sled of sufficient capacity to handle this amount of water was not available. Since there is a low area adjacent to the powerhouse with a natural drainage ditch to the bay, the water was pumped directly into this area where it froze. During the summer, this water drained through the camp adding to the drainage problem. The waste tank inside the building was then eliminated as it created an odor. Pontoons were obtained by Deep Freeze II to make a suitable waste water disposal sled if desired.

Deep Freeze II forces considered the Deep Freeze I "honey bucket" system very impractical. During storms it was almost impossible for a man to change the buckets. Therefore, they were constantly overflowing and freezing in place. The waste water and urine which drained behind the heads froze and caused large ice formations. There was a constant odor of urine and waste water with this method.

During the isolation period, sealed 150-gallon storage tanks were installed in all heads to collect waste water and urine. They required emptying about once a day. For this a 2-inch steel outlet pipe was attached to the tanks and connected just outside each building to a 4-inch neoprene hose. The hose lines were pitched and laid on the surface for over 100 feet away from the camp area. The hoses operated in the coldest weather except when someone left the tank valve on and water trickled into the hose and froze. For solid waste, "honey buckets" were used. The water from the showers and laundry located in the powerhouse was merely piped outside the building. In winter this caused a large accumulation of ice, but in the summer the ice melted and it drained away with other melting ice and snow.

The washwater and other liquid wastes from the galley were drained into a 150-gallon tank that was sealed except for a ventilating pipe that allowed the foul air to escape to the outside. A small 1/2-hp pump was installed in the outlet side

of the tank, and after each meal the waste water was pumped through a hose to a 4-inch line on the outside of head No. 4 that carried it down to a run-off area on the side of the hill. The tank was scoured with hot soapy water weekly, and all obnoxious odors disappeared. Garbage was collected in cans. A separate can was used for food and another for wastepaper. These cans were placed on a sled and hauled to a dump on the edge of the ice below camp and burned.

Recommendations

1. That Deep Freeze III training include disposal of wastes.

2. That a study be undertaken to determine if treatment of human wastes is feasible. Some form of chemical spraying or additive is considered desirable.

3. That slaked lime should be used in the fecal drums, winter and summer.

Little America

Each head had a three-seat commode covering a 8-foot by 6-foot by 8-foot hole. It was found during Deep Freeze I and II that the depth of 8 feet was not sufficient, as the pits slowly narrowed. Existing cracks fashioned by the water which drained from showers and washing machines were enlarged by judicious use of dynamite (C-4). With the hole in head No. 13 in some places 88 feet deep, satisfactory results were achieved. Icy drafts blowing up through the holes caused some discomfort and definitely prevented any time being lost by personnel lingering. It became a routine task for demolition personnel to keep the pits cleared. The latrines developed an offensive odor from time to time. There was particularly a strong odor of ammonia, which was probably due to breakdown of nitrogenous materials in urine. This odor was present despite extremely low temperatures (constant temperature of -20 F).

Garbage was left outdoors behind the galley and then carried by tractor to a clearly marked rubbish area and buried in the snow. Rubbish was deposited on trash sled and emptied twice a week with the garbage. There was no means of installing a dishwashing machine. All dishes washed by hand thereby making it impossible to use sufficiently high water temperatures to assure sanitary dish washing. Highest possible water temperature was used by having dish washers wear heavy rubber gloves to protect hands from scalding. The major source of danger in the galley lay in the cleansing of the coffee cups which were in almost constant use. A three-stage dip was used to clean cups after use, detergent and two rinses. This was finally improved upon by an additional dip of dichloran antiseptic (after detergent had been rinsed). Most galley equipment was kept in clean condition, and no special sanitation breakdowns occurred.

Byrd

The deep pit under the head for body waste proved highly satisfactory. This pit was 16 feet deep. The temperature in the pit remained around -25 F. The combination of the cold, the forced ventilation down past the seats, and the urinal prevented any unpleasant odors. In September, the pit level rose to within a few feet of the seats and the lightly packed mass was reduced using streams of hot water.

In the mess hall both sinks were piped together inside the building, and one 2-inch drain pipe ran through the floor and emptied into the snow under the building. Garbage and trash was hauled once a week throughout the winter by a crew of four men using a banana sled. Handling of wet garbage was improved by using empty weather bureau cans as disposable receptacles. The fresh garbage was poured into the cans, placed outside the galley to freeze, and then collected each week and hauled to a pit. When possible, the trash and garbage in the pit was burned with the help of old engine oil. This allowed the mass to sink below the snow surface level and thereby diminish the tendency for such an area to cause drift. Before this measure was used, one garbage pit produced a small hill.

South Pole

There are two main factors about the South Pole Station which make it somewhat unique so far as sanitation is concerned. First, the base rests on snow which is 8200 feet deep. There is no rock, soil, or permafrost in the neighborhood. Second, the average yearly temperature was -55.8 F, and at no time during the year does the temperature rise above 0 F. A third factor is the altitude of 9200 feet.

Because of limited medical facilities and because the wintering parties would naturally appreciate a clean and sanitary camp, every effort was made during the construction period to preserve the natural cleanliness of the area and to limit contamination to well defined areas. As soon as the construction camp area was staked out, a dump was established on the lee side of camp. All refuse was placed in this dump which consisted of a hole roughly 15 feet in diameter and 10 feet in depth. As the hole was filled, the refuse was burned.

A pit-type latrine was dug and covered with a large box cover. Over this was erected a tent. The disposal system was effective and odor free. The area was well marked to prevent future contamination. In order to save travel time during the sleeping periods, a half barrel was placed adjacent to Jamesway No. 2. The head tent and barrels were used until the latrine was completed, at which time the head tent was abandoned.

The latrine served not only to provide disposal facilities, but also served to provide washing, drying, showers, and lavatory space to increase the comfort of the crew. Practically no laundry had been done prior to the completion of this facility.

Waste water from the lavatory and laundry is temporarily stored under the lavatory in a waste water tank. When this tank (180 gallons) becomes full, it is pumped by a small-capacity electric centrifugal pump into the pit where the temperature is generally -40 F. By emptying large quantities of water at any one time, the pit deepens somewhat, but the overall trend (by Deep Freeze II) was the filling in of the area. The galley water waste collected in the sink is drained into the large pit under the sink. As this pit, too, is slowly filling, future pits should be dug deeper and wider at the start.

The facilities in the permanent head were adequate in all respects. The building was centrally located, warm (55 to 75 F), and well lighted. There were two sinks with hot and cold running water, a shower stall, a washing machine, and a drying machine in the head. Hot water was always available. By experience it was found that the seats must be placed squarely over the middle of the pit. If placed near a side of the sewage pit, the collection of urine and feces soon builds a shelf which protrudes and requires periodic clearing. At the beginning of the year, a small exhaust fan drew air out of the pit through a stove pipe out the roof. Later it was found that this was quite unnecessary. The frozen sewage was quite odorless and unoffensive if left unventilated.

A seat arrangement was devised to reduce the unpleasantness of the frigid toilet seats. Both seat and lid were left raised, and the hole was covered by a third hinged lid of plywood when the seat was not in use. This system raised the seats to room temperature while they otherwise would have been at -10 to 30 F. The matter of urinals also received considerable attention. It must be understood from the start that any pipe which emerges from the buildings will inevitably freeze if water passes through it intermittently. The system of a pipe within a pipe was therefore set up. Although urine passing through the inner pipe might freeze, the system allowed the removal of the plugged inner pipe for thawing.

Garbage disposal is very simple on the Polar Plateau. A pit is scooped out of the snow, and the garbage and trash is periodically burned in it. Any outdoor pit is soon doomed to be filled with drifting snow so the system is far from perfect, and trash on the surface is apt to be blown by the wind. This problem raises the question about the advisability of a good incinerator. It is recommended that an incinerator be installed in the tunnel system close by the galley. Much of the galley waste can be disposed of down the galley drain. Here again a simple pit below the galley sinks is quite adequate, and there is enough hot water drained from this source so that the pit is self-perpetuating.

Hallett

During the initial construction period a field head was utilized. It was located 100 feet west of the temporary camp. Upon completion of the permanent head, this field head was covered with gravel and the stools were stored. Empty 55-gallon oil drums were cut in half and used for the collection of excrements. These were sprinkled with soda lime to decrease the smell and were dumped weekly on the bay ice adjoining the base one-quarter mile from the main camp.

Water drainage systems were very poor. During the construction period a drainage tank was placed under the sink in the galley which was drained twice daily. The heat from the building caused the food wastes to ferment and give off a rancid smell. As soon as the construction battalion left, this tank was removed. A drainage pipe was installed through a hole in the wall. This also caused trouble because of pooling and freezing of the water. This problem was solved by frequent removal of the ice and pumping out the pooled water.

Shower drainage in the head was better. Water ran downhill for quite a distance before there was any chance of pooling. However, the drainage from the sink and the washing machine had to be discontinued due to freezing of the hose and snow drifting against the side of the building. Buckets were then used to collect water from the sink and washing machine and were emptied down the shower drain. There was no drain for the darkroom sink, and a bucket was used directly under it. The drain in the sick bay sink was of a small diameter which caused it to freeze very often, especially during the winter.

Wilkes

The plumbing system as designed and installed was unsightly, unsanitary, and impractical. The system was completely changed and operated very well after modification. The success of some of the methods used are due to the local situation at Wilkes Station and would not be applicable for antarctic stations in general.

The galley and washstand waste water system originally emptied into large open rectangular tanks which in turn drained under the buildings. The open tanks were objectionable, and the mess under the buildings was foul smelling and unsightly. The tanks were removed and replaced by a length of 2-inch pipe which gradually sloped downward from the galley to the head and terminated 44 feet beyond. All sections outside the building were insulated with glass wool inside a wooden servidor, and the final section was heated. All liquid waste was carried by this pipe which did not freeze up at all after the installation was complete.

Originally the urinal emptied into a drum immediately outside the head. Later it was connected to the drainage pipe. Drums were set beneath the stools so that they could be removed from outside the building and were disposed of in the adjoining bay. With drifting-in, this became impractical. The space under the stools was enclosed, and two exhaust fans were installed. This made the stools warmer and reduced the odor considerably. The stool section was made removable and a stand built inside the enclosure to hold standard garbage cans tightly against the holes. The cans were removed from the inside after having covers placed on them and were then carried outside to the garbage sled and emptied into the bay. The Wilkes Station site afforded excellent drainage, and this is a must for bases sited in rocky areas.

Ellsworth

Human wastes and wash water were adequately disposed of by draining them into covered pits in the snow. The latrines and water closets at the station were sanitary and very satisfactory. The following suggestion is made: pits should be dug about 20 feet deep and when possible located centrally beneath the building foundation. Pits beneath the heads filled rapidly. The drainage pit beneath one corner of the galley, in addition to heavy equipment in that corner, was believed to have made the building settle more in that corner than in the others.

Garbage and refuse disposal was at first accomplished by placing it on a pile about 100 yards from the camp. This, however, was not satisfactory because the wind blew much of the garbage about. Afterwards shallow pits were made in the snow and the garbage dumped in these and covered with snow. The garbage and refuse was collected in a 10-ton sled and dumped when it was full.

LAUNDRY EQUIPMENT

McMurdo

Laundry facilities located in the powerhouse at McMurdo were inadequate (1956). Only three washing machines and six driers were available, and parts for these were scarce, as was technical manpower to make repairs. The washing machines were heavily used; people tried to do laundry in them all winter; in the summer, the load on them was that of 300 more people. The system of everyone washing his own clothes proved adequate through the wintering period, but the equipment did not have sufficient capacity for the summer population.

Early in the year the driers were no longer used because the lint which they expelled into the building was a fire hazard in conjunction with the 100kw generator that was always running. Clothes were cried on lines strung in the overhead of the powerhouse and in the barracks. It was a "make-do" situation during the wintering period, but during the summer season it was an impossible situation under such crowded conditions.

Little America

An agitator, spin-drier type washer was used at Little America, as well as an automatic. The agitator type is preferable because of its durability, water-saving characteristics, and ease of operation. The automatic consumed several complete changes of water, and the timer was a constant maintenance problem since many different people used the machine in different ways.

Recommendations

1. A wringer-type, rather than a spin-type, extractor is recommended for its ease of operation.

2. At a station the size of Little America, a shipboard-type laundry facility would be ideal.

3. There would be a saving in time and water if one man were assigned full time as laundry operator.

Hallett

Two automatic washing machines and driers were received at this station. During off-loading, the washing machines were subjected to salt-water immersion. No spare parts were available. However, by cannibalizing one washer the other unit was made serviceable. Both the washer and drier received heavy use and did not prove quite equal to it. They were noisy and erratic in operation by the year's end. Service manuals were not furnished on either machine. As a water-conservation measure, the washing machine was modified to eliminate all but one rinse cycle. This type of washing machine requires too much fresh water for an isolated station. Any machine furnished should be accompanied by a liberal spare parts allowance.

GALLEY EQUIPMENT

McMurdo

The galley ranges were a continuous problem. These ranges were fired with a rotary-type oil burner and were in operation 24 hours a day. The wear on parts was great. The intense heat required to heat the cast-iron plates of these field stoves often caused the rotor tips of the burners to burn; the oil would then be distributed improperly, and a great deal of carbon would form. The oil and air mixture gave considerable trouble. With constant use, the dials and setting screws became worn; and the settings were never proper according to the gauges. Each setting had to be made by the judgment of the repairman. Also, since the outside oil supply was of a relatively low temperature, the oil would heat and expand in the oil lines that ran behind or near the ovens. This expansion caused air pockets in the burner and oil lines, and bleeding of the burner was quite often required. Finally, a 5-gallon oil tank was mounted on the wall behind and between the stoves and filled by turning a valve on a line to the outside storage tank. This small tank allowed the oil to warm to room temperature before using. After almost two years of constant use, these ranges were about burnt out. The plates are warped from heat, the fire chambers were broken, and the burners themselves were in poor condition.

The bake ovens had to be replaced after only two months during Deep Freeze I. This was probably due to bringing them to a maximum heat over too short a period of time. A new oven was installed (in 1957) and the existing one rebuilt, because a year of constant use had burned large holes in the back steel liner which allowed fumes and soot to enter the baking chambers. The ovens burn oil and use a gravity-flow carburator which requires frequent cleaning. The major problem with this type of oven was that a constant even heat could not be maintained.

Byrd

Galley equipment included a Shipmate range converted to diesel burning without heat control, and an electric coffee and hot-water urn, which was damaged in airdrop but was functional after some welding. A diesel-burning water heater, set at 140 F, heated water for an overhead storage tank and for circulation through the galley snow melter. A four-piece electric toaster functioned poorly. Tables were covered with Masonite and easily kept clean. Bake ovens and a proof box were not available, which made baking in the single oven at the 5000-foot altitude difficult. A shelf constructed behind the range, which maintained a constant temperature of 80 F, was used for the bread to rise.

South Pole

The galley range was a Shipmate Model 4JO, which did the job but created an excessive amount of soot. A larger range was recommended for Deep Freeze III. The stove was the main source of heat for the entire mess hall. It served well until a partition was erected to divide the building in half because the grease from cooking was fouling the meteorological instruments. An adequate hood, perhaps with a circulating fan above it and an exhaust fan below it, would give more efficient heating.

Hallett

The galley range was a diesel-fired unit which required much attention and cleaning. It is believed that a small restaurant-type electric range would be more adequate for this station.

Wilkes

The South Bend oil range in the galley was very dirty in operation and required a great deal of cleaning. Operation was somewhat difficult to control and it was difficult to maintain a satisfactory draft. An adequate exhaust hood was not furnished, but one was fabricated locally. This proved satisfactory except for cooking grilled steak dinners.

Ellsworth

All equipment and utensils were adequate with the exception of the oil-burning range. A smaller electric or gasoline range would serve more adequately and be much less trouble to maintain. Although the manual of operation is included with the Army Field Range, it is recommended that some practical experience in operation and maintenance be provided commissary personnel prior to use of this equipment in field work. The field galley equipment performed excellently under the circumstances. However, for cold weather use inside huts a vent system is required. It would be preferable if the ranges were converted to burn diesel oil prior to shipment. The kits furnished to convert the ranges from gasoline to diesel oil fuel were for a different model range. For the use of the ranges inside huts the use of diesel oil as fuel is preferable from a safety standpoint.

FIRE PROTECTION AND FIRE FIGHTING

McMurdo

Uncontrolled fire is the greatest hazard to the welfare of personnel and operational capabilities of an isolated antarctic station. By the end of March 1956, the CO detectors were in operation in all living quarters and working spaces. The PA system had been installed in all buildings. The siren was dismantled from the Ontos and mounted atop the photo lab as part of the fire alarm system. Absolute protection from fire damage is impossible for fires may be started by nature, sabotage, equipment failure, personal carelessness, or material failure. Therefore, every organization must analyze its own situation and adopt a course of action suitable to its situation and in keeping with an acceptable element of risk. McMurdo buildings used the year around had the following minimum equipment: one 15-pound Ansul and one 25-pound liquid hand extinguisher, one 150-pound stationary Ansul extinguisher, and an axe and shovel in each entry. The camp had four 300-pound Ansul extinguishers that were mounted on large wheels and placed stratigically around camp.

Initially, fire-fighting equipment consisted of two sled-mounted, 500-pound Ansul extinguishers. Later a wheeled trailer, mounting three 150-pound Ansul extinguishers, was utilized. It is believed that this latter type is better suited to the conditions of McMurdo. On the one occasion when this equipment was used on an aircraft fire, the 500-pound type did not operate due to leaking fittings and clogged hoses. The three 150-pound Ansul extinguishers were sufficient in the hands of skilled operators to extinguish an extensive fire which gutted two engines and a portion of the wing on a C-124 during its landing rollout. As a result of this experience, an additional sled was fitted with three 150-pound extinguishers in lieu of the 500-pound one. While such equipment is adequate for limited aircraft fires, it is completely unsatisfactory for protecting the types of aircraft employed in this operation.

The runway and skiway each had a 1-ton sled mounted with eight 150-pound Ansul bottles. The sleds were parked about mid-point along each runway. For all landings and take-offs, a crash crew of five men and one hospital corpsman manned a weasel attached to the sled. In October 1957, a Dodge truck fitted as an Ansul fire truck was flown to McMurdo for added runway protection. It is understood that in January 1958 another similar truck arrived.

The most important buildings, powerhouse, mess hall, communications, aerology, and the barracks were occupied 24 hours a day. Shop buildings such as the garage, hangers, aviation electronics, and parachute loft were manned 24 hours a day only during the summer. These shops were secured by assigned personnel. This included

turning off the stoves, electric power at the junction box, and removing accumulated trash and fire hazards. The night JOOD supervised two men whose many duties included keeping a lookout for any indication of an outbreak of fire.

The most probable source of fire, other than human error, is from the stacks of galley ranges and other building space heaters. During high burning rates, many large pieces of burning soot were sometimes emitted from the stacks. Also if stacks became loose and touched the building openings, the intense stack heat could set afire the dry plywood building panels. After the Public Works garage and shop building was razed by fire and it was determined that it had been properly secured, it was more apparent that such important buildings must be inspected each hour or half hour even though all known potential fire hazards had been eliminated. Therefore, for the remainder of the winter nights and until summer operations kept the shops open 24 hours a day, a continuous roving fire watch was established for the inspection each half hour of all unmanned buildings with either heat or electric power on, plus important buildings even if heat and lights were off.

It was found that the only way to fight fire was to eliminate it prior to the first flame or to be on hand when the first flame or smoke appears. If the firemen cannot enter the building or see the base of the flames, they should salvage the material and equipment close enough to the building to be damaged, and then use a D8 tractor to shove-in the building sides and contain the fire.

Every permanent camp member was assigned to the fire bill with a specific responsibility. Enough individuals were assigned each necessary function, so that if half the personnel for some reason did not hear the alarm, fire-fighting equipment and personnel would arrive expeditiously and in numbers required. People were assigned to bring bulldozers, Carylifts, large Ansuls, hand extinguishers, ladders, shovels, and axes. Each man had to report to someone for further instructions. The fire chief and fire marshall gave instruction to small groups on the care and use of equipment, and the procedures that would generally be followed in the event of a fire. Sufficient drills were held to insure that everyone was familiar with their respective duties. The fire chief and fire marshall inspected all fire equipment periodically to insure it was in operating condition.

The fire alarm system installed by Deep Freeze I was connected to only seven buildings which were always occupied. The alarm system was not in operation upon the arrival of DET BRAVO, and instruction books were not available. Since the electrical and electronics personnel could not correct the installation, the system was not used. The PA system was much more effective for all buildings could be contacted.

Little America

Fire Protection

It is recognized that fire is the most serious threat in the antarctic because of the sub-zero temperatures and gale-like winds, inability to bring an appreciable amount of liquid extinguishing agent to bear on a fire, and the fact that for over nine months of the year it is not practicable to obtain any kind of replacement.

A fire bill was promulgated to reduce the fire hazard to a minimum, to establish a system of effectively combatting fire in and adjacent to the Little America Station, to acquaint personnel with the types of fire-fighting equipment available, its use and location, and to establish fire fighting procedures. All fire company personnel were thoroughly indoctrinated in the use of existing fire-fighting equipment, types of fires, and methods of combatting fire. Numerous surprise fire drills were instituted by the officer in charge simulating various types of fires and existing conditions. Discrepancies, whether large or minor, were noted and remedial action taken. Weekly inspections were made to insure readiness of all equipment. CO_2 bottles were weighed. Ansul units were inspected for broken safety wire seals, usage, or mishandling.

The base was divided into five major fire-fighting zones. Five pull boxes were located on the bulkhead in the passageway — one in each zone. Small hemispherical fire detectors were mounted on the bulkheads of most buildings to detect the presence of fires. When the manual or mechanical system was activated, the fire watch center (power plant generator watch) was alerted, and the passageway fire alarm horns were activated. The fire watch center informed the JOOD by phone immediately giving the alarm, the zone, and the cause if known. The JOOD immediately passed the alarm over the 24-station intercom.

A fire and security watch was initiated primarily for general safety. Normally, the watch stander made a complete inspection tour of all spaces each half hour. During storm conditions, hazards naturally increased. To combat this, an additional fire and security watch was appointed making it possible to have a continuous patrol. All buildings were inspected to insure that stoves were secured in unoccupied spaces and functioning properly in berthing spaces. The carbon monoxide detectors were inspected for operational status and carbon monoxide reading. Corrective action was taken where deemed necessary, and many potential fires and other hazards were eliminated. There were a few minor fires at Little America. However, due to the constant vigilance and alertness of all hands, especially the fire and security watch, and the high state of readiness of the fire company, the fires were expeditiously extinguished.

The large Ansul units are considered the best extinguishers for major fires in sub-zero temperatures with the following limitations:

1. Inability to bring an appreciable amount of Ansul powder to bear on high overhead surfaces.

2. Powder dissipation due to high wind effect.

The liquid extinguishing agent derived from LaFrance antifreeze crystals began to freeze at minus 20 F and is a poor extinguishing agent for antarctic use.

Carbon Monoxide Protection

Buildings constructed for antarctic use are necessarily tight and natural ventilation is poor. At Little America the primary means of heating was oil. This, coupled with tightly enclosed spaces, was naturally conducive to the accumulation of fumes. In order to reduce dangerous fumes, such as carbon monoxide, to an acceptable risk level in buildings occupied by personnel, carbon monoxide detectors were installed.

The CO detector manufactured by the Mine Safety Appliance Company proved very satisfactory. These units were located in all buildings occupied by personnel. They operated on 110 volts ac and consisted of a blower motor of 1/80 horsepower, an alarm horn, and a series of relays and indicating lights. A sample of the surrounding atmosphere was taken in through an intake port and passed through a chamber containing fine electrodes surrounded by a chemical which was heated to a predetermined temperature by the unit itself. This chemical was of relatively low conductivity until it was exposed to a specific amount of carbon monoxide, whereupon its chemical structure changed and provided a good conductive path between the electrodes in the detection chamber. Upon being exposed to approximately 1 percent of CO, the green or safe lamp on the panel would go off, and the red warning lamp would light, simultaneously setting off the alarm horn. The unit could then be reset to safe position. After two or three alarms, the chemical in the detection chamber would have to be replaced.

Recommendations

1. Periodic surprise fire drills and scheduled lectures should be given in order to keep the fire company in a high state of readiness.

2. Weekly inspections should be made of all fire-fighting equipment.

3. Stoves in unoccupied spaces should be kept secured.

4. A fire and security watch should be maintained especially during the winter period and when the base is operating on one shift. A complete inspection of the base should be made every half-hour. This watch must be doubled during storm (high winds) conditions and a continuous patrol maintained in order to guard against storm damage and stove blow back.

Byrd

Originally each building contained two Ansul hand extinguishers. However, the number was adjusted as considered necessary. A fire watch was established whose duties consisted of checking for fires and filling the space heater tanks. One D8 tractor was available at all times to drift snow onto a burning building. Upon completion of the tunnel, refill supplies were placed at either end of the tunnel, providing better distribution regardless of location of fire.

The automatic fire alarm system consisted of a main control panel with fire zone indicator located in the vestibule of the communications-meteorology building. Detector thermostats were located in all five heated buildings. The detectors were mounted on the overheads at spots estimated most strategic. Two manual pull boxes were installed, one in the galley and one in the powerhouse. Activation of the alarm caused a bell to ring in the mess hall and a horn to sound by the control board in the galley.

Due to limited equipment, the D8, weasel, or IGY Sno-Cat with two or more Ansul extinguishers were used to stand by during air operations. The IGY traverse personnel and equipment were available for off-station crashes. The weasel, with a man dressed in asbestos clothing and equipped with Ansul bottles, stood by each plane during starting and alongside the runway during take-off and landing.

South Pole

Fire Protection

During summer operations, fire watch duties were assigned to personnel working night shift. The limited number of personnel did not warrant the assigning of a specific fire watch. All personnel were well familiarized with camp security needs. During the winter night the fire watch was stood by the UT, who was assigned to working nights. He made hourly rounds of the base and also acted as generator watch.

Available extinguishers were six 20-pound Ansuls, thirteen Kiddie water extinguishers, and one questionable 150-pound Ansul. The latter was damaged in airdrop and later repaired. As it never had to be used it was not known whether the repairs were satisfactory. A request for additional extinguishers, both 20- and 150-pound Ansuls, was turned down in February 1957 by a task force message saying there were none available. However, in December 1957 additional units were furnished by McMurdo. Additional extinguishers were also included in Deep Freeze III resupply orders.

Fire Alarm System

The control panels for the Kiddie Fire Alarm are located in the mess hall with ten detectors and four manual alarm stations located throughout the base. Alarm sounders are located in the mess hall, the barracks building, and the science building. This system was operative throughout the year. In addition, field phones and a three-speaker PA system provide means of passing any alarm to all buildings except the head.

Hallett

Fire Alarm System

The fire alarm system was changed so that there were eight zones, each major building representing an individual zone. Under the original system there were four zones. All buildings, with the exception of the hydrogen generator building (Bldg. 6), were provided with thermal switch type alarms. All of these alarms were wired to the master fire alarm panel located in the mess hall (Bldg. 2). To insure that all hands were notified of a fire, all important buildings were equipped with a fire horn or buzzer which was wired to the master alarm. When the alarm went off the word was passed over the intercom system giving the location of the fire.

Fire-Fighting Equipment

Ansul dry chemical extinguishers are believed to be the best type of extinguisher for this type of operation due to their range of operation and usability in class "B" and "C" fires. One 150-pound unit was permanently located in the garage and a second unit was mounted in the weasel. This vehicle was designated as the crash and fire weasel. Nine 20-pound Ansul units were located through the camp. The 2-1/2-gallon Walter Kiddie antifreeze extinguishers were placed on the outsides of buildings throughout the camp area. During the winter months it was necessary to place them inside, as they froze at minus 20 F. The antifreeze mixture furnished

with these extinguishers was manufactured by the American-LaFrance Company. The 2-1/2-gallon foam extinguishers were kept inside the head building and were never used. The carbon tetrochloride vehicle extinguishers were no good once discharged as no replacement equipment was available.

Wilkes

One or more Ansul fire extinguishers were located in the galley, powerhouse, garage, communication buildings, and at other points where electrical fires were anticipated. Antifreeze water and 20-pound Ansul extinguishers were placed inside the entrance at each end of the buildings and at entrance ways to the tunnel between galley, head, and barrocks. A weasel was outfitted with ladder, axe, pry bar, line, and 20-pound and 150-pound Ansul bottles to serve as a fire vehicle. All vehicular equipment contained hand-operated carbon tetrochloride extinguishers.

The fire detector system, as installed and designed, for all practical purposes was useless. The thermal operated switches when tripped by very high heat would cause a lever to fall out on the locator board in the galley. This indicated the space in which fire was occuring and at the same time sounded a horn. This system did not function for the two building fires encountered. It was triggered accidentally by water seeping into the mechanism when a roof leaked. Experience at Wilkes Station indicated that by the time this system gave the alarm, the building concerned would be a total loss; and it would be difficult to prevent destruction of interconnected spaces.

The electric carbon-monoxide alarms were too sensitive to maintain an effective watch and were not used. Electric horns were removed from these and used with a manually operated fire alarm system. Switches in each building connected into this alarm circuit were operated manually as soon as a fire was discovered. This proved very effective in sounding the alarm.

For fighting fires, two men each were assigned to the following duties: bringing the ready tractor to the scene of the fire; awakening all station personnel; bringing the fire fighting weasel to the scene of the fire; bringing axes, prybars, and any other needed hand tools; and isolating the fire area electrically. Response to an alarm was very rapid and usually most personnel were at the scene within 60 seconds of the sounding of the alarm. All personnel not assigned specific duties carried hand extinguishers to the fire. The volume of the alarm was augmented by using the horns from the carbon monoxide alarms.

Four fires were experienced at this station. Two were in the inside of buildings protected by the automatic detector system. In both cases the detector did not operate. The first fire, in the powerhouse, was an electrical fire caused by ruptured insulation in the fire alarm circuit inside BX conduit. It caused minor damage to a wall panel before it was brought under control by de-energizing the fire alarm circuit and using a 20-pound Ansul powder extinguisher. The second fire, in the garage, was started by welding operations and caused minor damage. It was also brought under control by the use of the hand Ansul unit. The other two fires occurred outside of the area protected by the detector system. One was in the galley smokestack and was kept under control with the use of the mobile 150-pound Ansul unit. The other was in a small Jamesway hut which was being used to keep open a freshwater pond for a water supply. This fire started when a Preway heater backfired. The hut was a total loss, and the use of a 20-pound Ansul unit was completely ineffective against the blaze.

Ellsworth

During the first week that the camp was established a demonstration was given on the use of the large Ansul fire-fighting equipment. The station personnel was divided up into five fire-fighting units and a rescue unit. Two small Ansul extinguishers and in some cases a liquid extinguisher were placed in every building. One large Ansul unit was mounted on a small sled behind a weasel. This unit was fitted for the express purpose of combating aircraft fires. Fire drills were held regularly simulating various types of fires. Due to a low supply of chemical extinguishing agents, it was necessary to limit their use during drills in order to minimize waste and insure an adequate supply in case of actual fires. A triangle of steel which produced a ringing sound when struck was used as a fire alarm. This alarm was placed in the main tunnel outside the enlisted barracks but could not be heard during drills. A better type alarm system should be incorporated, possibly of the automatic type which could be heard throughout the entire base.

During the year there were three fires. The first occurred in the galley, under the bake oven and was due to insufficient insulation. It was easily put out with a small Ansul extinguisher. To prevent reoccurance, the floor under the oven was rebuilt and insulated with loose asbestos and covered with sheet metal. The second fire happened in the garage and was apparently from spontaneous combustion in oily rags left under a portable welding machine. The wheels of this equipment sustained considerable damage before the fire was extinguished by use of portable Ansul extinguishers. During this fire a large Ansul unit in the tunnel would not work. It was determined later that some of the chemical had been left in the rubber hose after a fire drill and had not been blown clear with nitrogen. The third fire started

just outside the mess hall. Sparks and hot soot from the galley range which was being cleaned ignited the burlap covering the tunnel. There was a strong wind and the Ansul chemical was blown off the burning burlap and wood before it could smother the fire. A pump-type water fire extinguisher finally got the fire under control.

The equipment for fighting fires was considered satisfactory. However, a larger supply of nitrogen for the Ansul units would have made fire drills more realistic.

POL STORAGE, DISTRIBUTION, AND USAGE

McMurdo

Storage Facilities

All POL in 16- and 18-gauge drums and cans was stored in a large dump area to the northeast of the facility. The dump was divided into several sections in case of fire. Bulk fuel was stored in two permanent tanks, eight 10,000-gallon rubber tanks and two YOG's. Bulk storage for Deep Freeze I was as follows:

Avgas	One 250,000-gal welded steel tank
Mogas	Eight 10,000-gal rubber tanks
Diesel	One 100,000-gal welded steel tank
White Gas, Avgas	Two YOG's - 250,000 gal each

The YOG's were moored north of Hut Point. They required daily inspection of anchor chains and lines as great pressures were exerted by tidal action and the breaking off of huge sections of the snow and ice cliffs alongside the mooring location. During Deep Freeze II an additional 250,000-gallon avgas tank was erected. All bulk fuel was delivered by means of the Marine Corps Bulk Fuel System, with the exception of that fuel which was stored in the YOG's. Drummed POL products were delivered to the edge of the bay ice by ships where it was transferred to tractor trains and hauled into camp.

Drummed fuel operations in Deep Freeze I were about as complicated as would be expected in the handling of 12,000 loose drums, each weighing 430 pounds. The procedure followed was to load the drums in 10- and 20-ton sleds which were towed by a D4 or D8 tractor to the cache site. Loose drums in the sleds shifted badly, destroying side boards, and on two occasions causing the sleds to turn over.

Unloading by barrel chimes was too slow. Drum handling crews of eight men manhandled the unwieldy items. The drums were rolled off sleds onto dunnage laid out on the ground. Two layers of drums were placed on top by the same method, the dunnage being removed as each drum came into place to permit nesting. The drum handling procedure, while fast and resulting in excellent storage, was hazardous to personnel. Several minor injuries resulted when drums got out of hand. One man was seriously injured when a drum got loose and struck his head.

The drummed storage area for Deep Freeze II was just off the ice of Winter Quarters Bay and along the Hut Point peninsula. The drums were laid on their side and stacked four to six high, and about eight deep against the hill. It was one long pile of about 200 yards. It was a fine looking cache but during the winter blowing snow filled in the area so that the top layer was buried 1 to 3 feet. Using lifting equipment, five men is the minimum number for loading and unloading drums — two in the sled, two on the supply pile, and one operator.

Issue Facilities

Diesel Oil. Diesel oil was required for the power plant, equipment, and building heating systems. Three 5000-gallon steel dispersing tanks were erected northeast of the power plant. Fuel was pumped from the 100,000-gallon tank at Hut Point to the nested tanks utilizing three-quarters of a mile of 4-inch hose. The terrain over which the hose lay had a rise of 60 feet. This system worked well all winter, and no difficulty was encountered with the pump or line although temperatures dropped to minus 70 F. The fuel was then fed by gravity to the powerhouse through a meter manifold. Drums were used when the 100,000-tank was empty. Fuel for the garage was stored in a 3000-gallon rubber tank bermed in above the garage. Drums were periodically used to fill this large supply tank. A tractor drawn diesel sled of 300-gallon capacity was constructed for fueling stoves and heaters throughout camp. The fuel sled, an Athey wagon with two 150-gallon tanks, was fueled either directly from drums, using a Barnes pump, or from the nested tanks at the powerhouse. The first two pumps threw rods after less than 20-hours operation. This was attributed to poor operating technique in starting. The third pump was rigged so that it could be removed from the sled and stored in a heated building when not in use. Just prior to reinstalling, it was fired off and permitted to warm up. This seemed to correct the difficulty as no further trouble was encountered. This same pump was used to empty drums and to drain fuel from several of the 10,000-gallon rubber tanks.

Mogas. The eight 10,000-gallon rubber tanks at Hut Point served to feed fuel directly to a ready issue tank which was fitted with a hose and nozzle. All the tracked vehicles could get gasoline right at Hut Point. As the ready issue tank was expended, it would be refilled from the other tanks. Also 16 drums would be filled with mogas periodically and hauled to the garage for use by the wheeled vehicles in camp. The nozzles were the only difficulty encountered with this system. The interval gaskets leaked and although replaced and different nozzles used, the difficulty persisted throughout the winter months. Although temperatures ranged down as low as -70 F and averaged approximately -35 F during the winter period, no difficulty was encountered with the pump which was left out in the open throughout the winter.

Aviation Gasoline. The main demand for avgas was at the runway, approximately 1-1/2 miles away from the storage tanks. A dispensing facility was prepared at the runway consisting of three 10,000-gallon rubber tanks and Gorman-Rupp pumps. A 4-inch hose was laid between the runway and the higher 250,000-gallon avgas tank. With a head of 70 feet, the fuel fed into the rubber tanks at a rate of 50 gallons a minute. The planes were serviced directly from sled and wheel mounted refuelers which were filled at the rubber tanks and towed to the planes. To give an idea of peak air operations, over 37,000 gallons of avgas were dispensed prior to 1 January 1957.

Although total storage capacity in Deep Freeze II was 1,000,000 gallons, the total amount that could be delivered to the runway was about 10 percent less. The tanks could not be sucked dry as the discharge valve is 10 inches above the tank's bottom. The YOG pumps did not operate, so a 4-inch hose was lowered through each manhole and the gasoline pumped out with a Gorman-Rupp pump.

Marine Bulk Fuel System

This system was the heart of all the POL bulk transfers at McMurdo. In early February 1956, the components of the system were laid out from Hut Point to the USS NESPELEN, a distance of some 4 miles. To assist in pumping, three booster stations were initially used. The first was located a mile and a half from the ship; the second, two and a half miles from the ship; and the last station at the base of Hut Point, three and a half miles. This last station was about 1500 feet from the avgas storage tank which was 60 feet above the pump. With the exception of the last station, all pumping was over straight and level ice. One 10,000-gallon tank was used per booster station. The initial pumping showed a very slow rate of flow although the pressure seemed normal. One reading was 26 gallons per minute at 90 psi. Believing the distance from the ship to the first booster pump to be too great,

an additional pump was installed 1000 feet from the ship's side. This failed to remedy the situation. Further inspection revealed several ice blocks within the hose itself. Clearing was accomplished by breaking the hose, using a hammer to loosen the ice, and allowing the ice to be either washed or pushed out. The resulting fuel flow was satisfactory.

Prior to the return of the task force in December 1956, the laying of hose, placement of pumps, and establishment of a temporary intermediate tank farm was commenced. The hose which had not been used during the winter night was stored on the hill above camp. Although tarpaulins had been placed over the hose, the ends of the hose were full of snow and ice. As no available building was large enough to accomodate the 50-foot lengths of hose, an area was prepared on the side of a hill for the task of removing the snow and ice. With one end of the hose elevated, a Herman-Nelson heater forced hot air through each piece until the ice and snow were completely melted. Following this, a large rag was pulled through to take out any foreign material that remained. Over 300 pieces were treated in this long and tedious manner. To prevent further filling with blowing snow, these sections were hooked together and laid out with seals being placed over both ends. Seven 10,000-gallon tanks were utilized for the tank farm. All hose and tanks available were gathered together to expedite the operation. This included temporarily demolishing the existing systems in camp and at the runway.

The USS NESPELEN arrived at McMurdo Sound on 20 December 1956 and anchored roughly 16 miles from Hut Point. The icebreakers proceeded to cut a channel to a point approximately 8 miles north of Hut Point. At this point, icebreaking was halted as it was feared further disturbance might endanger the ice runway. Only 5 miles of assault fuel hose were available at Hut Point, not enough to pump directly to the YOG's and fuel tanks. Late in the month of December, 20,000 feet of new hose, three 10,000-gallon tanks and three 3000-gallon tanks were received, plus assorted short pieces of suction and discharge hoses. A temporary fuel farm was set up on the sea ice at a point approximately midway between the ship mooring point and Hut Point.

During the icebreaking operation, and for two days following, persistent northerly winds kept the channel clogged with broken ice. This made it impossible to move the NESPELEN to the mooring location. Since it was impossible to determine how long this condition might exist, it was decided to commence the unloading by transferring blocks of 25,000 gallons of gasoline to the USS GLACIER and shuttle it to the pumping point. Four trips by the GLACIER loaded the temporary fuel farm. Gasoline was pumped through a series of booster stations, the first 1-8/10 miles from the ship, the second and third at equal distances, and the last

1-7/10 miles from the tank farm, for a total of 7 miles. One 10,000-gallon rubber tank per booster station was utilized. Prior to disconnecting this first 7 miles of hose, compressed air was fed into the line, and approximately 70 percent of the fuel in the lines was realized as an end product at the temporary tank farm. At this point, it became necessary to retrieve the 7 miles of hose, lay it out on the opposite side of the temporary fuel farm, and connect it with the permanent storage at Hut Point. Once again, compressed air was used to salvage approximately 70 percent of the fuel remaining in the hose. A total of 95,000 gallons was pumped in this leap-frog operation.

By 29 December, the channel had cleared and the NESPELEN was brought to the mooring site which by that date had been moved to a point close enough to permit direct pumping to Hut Point. This speeded up what would have been a slow, arduous process; and by 31 December, when pumping was completed, 755,000 gallons of aviation gasoline had been delivered.

During the leap-frog phase the hose was manhandled and placed on 1-ton sleds connected in train for transport. Six sleds with the end boards removed permitted approximately 50 pieces of 50-foot hose to ride safely above the snow and ice. Weasels were used to pull the sleds. This was an excessive load for the weasels, and the transmissions particularly suffered as a result. However, in view of the dire shortage of tractors, no other solution was available. Eight to twelve personnel were required on a 24-hour basis for the operation. This requirement seriously restricted the work force available at the base at a critical time in ship off-loading and runway repairs. Three weasels were continuously tied up. The only difficulty encountered throughout the POL off-loading was that one of the pumps became completely inoperative due to engine trouble; and two others temporarily failed to keep up the required output and hence were immediately replaced with other pumps.

Although the gasoline was all delivered by 31 December, POL crews were required until the middle of January to gather up equipment, reinstall the tank farm system at the runway, and to assist at Little America. Three-quarters of a mile of hose, two Gorman-Rupp pumps, and eight 10,000-gallon neoprene tanks were loaned to Little America, together with supervisory personnel. Altogether approximately 4500 man-hours were required to accomplish the off-loading of all gasoline, including demolishing and restoring facilities at camp and runway.

"Between 26 January and 21 February 1956, the Amphibious Assault Bulk Fuel Handling System was laid out on the bay ice, connected, and utilized for pumping 230,000 gallons of avgas, 82,000 gallons of mogas, and 72,000 gallons of arctic diesel fuel. Due to operational schedules, the hose was laid two and one-half weeks before pumping commenced. In future operations, it is recommended that the system be laid out no more than two or three days before pumping. Dunnage was found to be unnecessary. No appreciable settling of the hose due to melting.

"Camlocks did not show any unusual amount of breaking during operations when temperatures ranged from -2 F to -30 F, and only four were broken during the entire operation. A simple cap of metal or plastic should be devised to cover the hose ends, snow and ice were constantly blowing into the hose prior to coupling and created a great deal of extra work. Water posed a constant problem, causing ice blocks in the system during initial pumping operations. After ice was freed from the system, a lengthy process entailing trailing from hose to hose, breaking the coupling and removing the ice, the system operated at an average capacity of 10,000 gallons per hour. Salt water was not used to purge the system due to the belief that it would freeze. Instead, to prevent the loss of arctic diesel in the line, it was followed by a slug of shipboard diesel.

"The 10,000-gallon tank at each booster (pump) station served as an excellent settling tank. Booster stations No. 1 and No. 2 were found to contain approximately 2 tons of frozen water and sludge after the pumping was completed; while station No. 3, the last station before the tanks, contained neither water nor sludge.

"The tanks and hose developed no unusual problems under the conditions to which they were operated. Although several Gorman-Rupp pumps became inoperative, this was not attributed to either the cold weather or the ice. The fuel-handling system is considered to be an adequate and satisfactory means of transferring fuel in the antarctic."[4]

The POL hose is the only quick and relatively easy way of transferring fuel in the antarctic. The hose should be transported on three 10-ton sleds, coupled one behind the other, so that the ends do not drag in the snow or dirt, or no part of the hose drags excessively or is pinched. When the hose is disassembled, each section should be immediately capped on both ends to insure that dirt and snow do not plug the hose or damage the ends. The hose sections should be stored on the side of a hill or a large flat area where they can be laid out side by side and not piled one on top of the other, and where there is no danger of vehicles driving over them. The rubber tanks are constantly subjected to weather and become checked and cracked. It is doubtful if they will last much more than one winter. Ample spare 4-inch gaskets should be shipped each year. The Gorman-Rupp pumps are versatile, and can be used as defuelers as well as direct pumps.

Auxiliary Equipment

The Air Force refueler, Type F6, 5000-gallon capacity, proved to be a superior piece of equipment in all respects. It is completely winterized and pumps at a rapid rate (5000 gallons in eight minutes). It is highly recommended for future operations of this type. In addition to the two F6 refuelers, a Navy type 2000-gallon sled

mounted refueler was available. Due to inadequate winterization, this refueler was not used until temperatures rose enough to insure comparatively easy starting of the pump engine (+28 F or better). The F6 refuelers were operated without difficulty through temperatures ranging down to -40 F. It is noted that the fire extinguishing system incorporated as a part of this refueler was very efficient. A fire broke out in the hose compartment of one of them and was promptly extinguished by manually tripping the CO_2 mechanism. The system had an automatic feature which may or may not have worked, but no one wished to take time to find out. The two Air Force refuelers were used to pump over 600,000 gallons of aviation gasoline during the period 18 October 1956 to 1 February 1957 without any serious malfunction.

Dispensing lubricating oil to the aircraft proved to be the most difficult problem encountered as the equipment on hand was not adequate. An Arctic Lube Oil Carrier, procured from Naval Civil Engineering Laboratory, Port Hueneme, was poorly fabricated and too flimsy for the constant movement required. It consisted of a sled-mounted 500-gallon tank incorporating a circulating antifreeze system with two heaters, a gas burning coolant heater, and an electric hot spot heater. The latter was satisfactory when ample power was available. The oil, after being heated, was supposed to be pumped to the aircraft oil tanks by two electric aircraft type fuel pumps. The pumps, designed for gasoline, did not have enough capacity to raise the oil to the aircraft wing and hence were never used in this manner. Instead, the warm oil was pumped into 5-gallon cans; and then the cans were hauled upon the plane's wings with a line. As the C-124's frequently used 100 gallons of oil at a time, such a process extended the servicing time unreasonably. A standard oil truck, properly winterized and equipped with an external heating unit, would have encountered little difficulty if used on the ice runway.

Quality of POL

In general, the bulk fuel was considered dirtier than desired, although no engine failures were experienced. This fuel condition was believed due to multiplicity of handling. Several times, fuel had to be transferred from one ship to another to meet ship movements. There was a great deal of water in the fuel in spite of every effort to exclude it. Fuel filters constantly froze although personnel were indoctrinated to take the utmost in care to prevent contamination. Alcohol was added to each tank of fuel, the quantity depending on the fuel. About 1 quart of isopropyl alcohol was added to each 25 gallons of mogas and to each 50 gallons of diesel. Some of the bulk diesel delivered was so contaminated that it was used only as emergency fuel.

The following is a résumé of fuels and lubricants used:

1. Premixed permanent type antifreeze was used in cooling systems and was satisfactory in the temperatures encountered.

2. 9170 motor oil was used in main engines except in extreme cold weather and then changed to sub-zero oil.

3. Sub-zero or arctic lube engine oil was used in air cleaners, starting engines, master clutches, steering boosters, and fuel-injection housings. Lube oil consumption during Deep Freeze II was considerably higher with arctic lube. There were no engine bearing failures caused by the oil.

4. Gear Oil Special (GOS) MIL-L-10324 was used in starting-engine transmissions, bevel gear compartment, final drives, and winches. It proved satisfactory in all temperatures. During Deep Freeze II, GO-75 was used with satisfactory results until March 1957.

5. Arctic-type diesel fuel VV-F-800 was used with a minimum amount of foreign matter to be found in fuel system. During Deep Freeze II, about 10,000 gallons of diesel were used per month.

6. Aviation-type hydraulic fluid Mil Spec 5606 was used satisfactorily to temperatures of -75 F.

7. Automotive gasoline was arctic-type Mil-G-3056 (Arctic C mogas made by Peerless Solvant Chemical Company was no good. There seemed to be no water in it but would freeze as it vaporized and formed red rust on carborator.[7])

8. Arctic-type grease, MIL-G-10924, was used at all temperatures and was satisfactory.

9. Alcohol, denatured, Grade 3, Fed Spec 0-A-396, was used as an additive to counteract water in both diesel and gasoline tanks with little help noted in some cases, and positive results in others.

Recommendations

1. That investigation be made into methods of unitizing the drums into units easily handled by fork lift and crane.

2. That every effort be made to bring tankers close enough to storage tanks to permit direct pumping.

3. That the use of steel spiral welded pipe in lieu of Marine Assault Fuel Hose be investigated. It is believed that substantial savings in money and weight could be effected.

(Note: Since preparation of this report, such action has been initiated by COMNAVSUPFOR ANTARCTICA and COMCBLANT.)

Little America

Method of Delivery

POL products were transported from shipside to storage areas in drums and tanks during early 1956. During Deep Freeze II, only avgas was in bulk. All diesel fuel was in drums and was loaded into tractor drawn 20-ton sleds at shipside, using ships' cargo booms, and transported to the fuel storage area. The drums during Deep Freeze I, were stored by hand in rows on wooden dunnage. Unloading sleds could have been accomplished much faster with cherry pickers.

The 20-ton sled can carry 72 drums and the 10-ton sled, 40 drums. During Deep Freeze II, the drums were mixed by type, and therefore segregation was impractical. At the intermediate supply dump the drums were pushed off the sleds in long rows as the sled was towed down the row. Attempts were made to keep the rows one drum deep to ease future handling problems; however, speed of unloading and insufficient equipment dictated that considerable drums be piled in tangled masses.

Mogas came in bulk for Deep Freeze I and was transported from the tanker to the storage area in 800-gallon aluminum tanks. Two sleds, each with five 800-gallon tanks lashed on them, were used to transport the mogas, moving a total of 4000 gallons per sled per trip. Ten rubber tanks with a capacity of 10,000 gallons each were used to store the mogas. The rubber tanks were set in depressions in the snow, and during the winter were completely covered over with snow with no adverse effects being apparent. The mogas was pumped from the tanks mounted on the sleds into

the 10,000-gallon rubber tanks using 350-gpm pumps. For Deep Freeze II, mogas was received in drums. It was later pumped into 800-gallon tanks, transported to camp and transferred to the 10,000-gallon tanks.

Avgas for Deep Freeze I was transported in bulk and was moved from the tanker to storage by the same method used to transport the mogas. The avgas was stored in a 100,000-gallon welded steel tank, approximately one and one-half miles from Kiel Field. "The aviation fuel tank (2500 bbls) was started on 17 January 1956 and completed, ready for fuel, on 30 January 1956. The footings for this tank consisted of pallets placed side by side and tied together with 1-inch by 8-inch pieces of dunnage. No settlement of the tank was noticed during the first two weeks after completion."[8] For Deep Freeze II the avgas was pumped directly from the tanker to the 100,000-gallon steel tank and 10,000 gallon rubber tanks using the USMC assault fuel system. Since the total length of hose was approximately 3 miles, three booster stations were employed along the way. The whole operation including the laying of hose, pumping 122,000 gallons of avgas, and picking up the hose was accomplished uneventfully. By using radio equipped weasels at each pumping station, at the ship, and at the steel tanks, proper liaison was carried out thus insuring successful completion of the job.

Issue Facilities

Three 5000-gallon steel tanks were erected near the powerhouse to stock diesel fuel for use throughout the base. The tanks were kept filled as needed by bringing in drums of fuel from the diesel farm and pumping the fuel into the tanks. The storage tanks were erected as one of the last outside projects with temperatures in the range of -30 F. When filled, they were to last through the winter night making it unnecessary to send personnel out to bring in drums of fuel. However, the fuel was not used until the following October under the assumption that when the tractor train personnel left there would not be enough men at Little America Station to bring in drums of fuel, and so fuel in the storage tanks would be used at that time. As it turned out, such was not the case; and there always were sufficient personnel aboard to bring in fuel. However, because of this policy it was necessary to send personnel out during the winter night to dig out and bring in drums from the farm.

Fuel was distributed from the drums to the tanks of heating units throughout the camp. Five-gallon blitz cans were used to transfer the fuel from drums to heater tanks. The blitz cans were drawn on a small sled from building to building within the tunnel. The galley tank being of 275-gallon capacity was filled from a drum. The same method was used to fill the two 275-gallon tanks in the powerhouse, the fuel being transferred from the drums to the tanks by hand pump. When the 15,000-gallon storage tanks were used, the powerhouse tanks were filled directly from the storage tanks.

Avgas was pumped from the 100,000-gallon storage tank, using a 350-gpm pump, into a refueler mounted on a sled. From there it was pumped into the planes using the pump on the refueler. This method was used to insure that the avgas would be filtered in the refueler before going into the plane tanks. However, the refueler is not movable when full. Consequently, to refuel, the aircraft taxied a mile and a half to the refueler. The arctic oiler worked very well. With four drums of 1065 oil in the tank, the electric heater alone would keep it at 40 F with an outside air temperature of -25 F. No troubles were encountered with the equipment after initial installation. During Deep Freeze II, the refueler tank was situated at the aircraft parking area along with a 10,000-gallon rubber tank. The rubber tank was maintained full by transporting fuel from the main storage tank to the rubber tank by use of sled mounted 800-gallon tanks. Thus, a reserve was always available at the field, and all fuel could be directed through the filtering system of the refueler tank.

The lube oil carrier shipped to Little America V was designed and constructed by the Naval Civil Engineering Laboratory, Port Hueneme, California. Many leaks were found in the heater coolant coils due to pipe fittings not being tightened.

"The heater coils in the tank were also full of leaks in solder/braze joints. The battery charge wiring had many shorts and cold solder joints and consisted of odds and ends of wire. Many were incapable of carrying the element loads. Heavy duty heat coils in storage tank had many loose joints. Their welded supports were only tack welded with insufficient penetration to the extent that they are broken off. No support is provided for the heat coils in storage tank allowing the coil to vibrate and chaff holes in it.

"The tank thermometer was missing, and no instruction plate was provided for operations instructions. Inlet/outlet valve positions were not labelled. Pump motor switch labels were ambiguous as to which position is discharge and which suction.

The mounting holes in the drawbar through the sled runners are drilled through wood. Without reinforcement the tongue immediately split out of the runners when pulling with the tank loaded. Being skid mounted, the lube oil carrier was difficult to maneuver, as snow would build up when the carrier was being towed or backed up.

"The rate of back suction is so low it is almost useless. Using the present transfer pumps and pumping 1065 oil, the pump draws a minimum of 18 amps with the oil temperature in excess of 65 F. The rating of the pump is 12.5 amps maximum. The Naval Civil Engineering Laboratory instructions specify 15 amps."[26]

After the unit was repaired and tested, it was set up at the air strip as a stationary unit for use in heating aircraft engine lube oil. The heating unit operated satisfactorily.

Recommendations

1. That on any future operation drummed fuel be segregated in loading aboard ship to insure proper segregation at off-loading.

2. That in future operations bulk fuel with the necessary number of tanks (either rubber or steel) be used. Much valuable time is wasted handling drums, and much more inherent danger to personnel exists in drum handling than in bulk fuel handling.

3. That as much fuel as practicable be stored in bulk. If at a temporary station, rubber tanks will be adequate. At a permanent installation, steel tanks should be used.

4. That drummed POL should be stowed so that a minimum of drifting will occur. An answer may be to pile the drums in long rows paralled to the direction of the prevailing winds, leaving space between the rows to allow passage of bull-dozers or other equipment to be used in recovery. It must be remembered that adequate flagging is a necessity.

5. That the following modifications be made to the lube oil carrier:

(a) Provide an external 24-volt power source for the pumps as single phase ac power is seldom available in field.[26]

(b) Waterproof the motor switches as the coolant and melting snow works into them causing shorts.[26]

(c) Provide shutoff valve in the battery heat inlet line.[26]

(d) Provide a drain in the coolant outlet pipe with a plug.[26]

(e) Mount the unit on a suitable sled.

Byrd

All POL was received by airdrop with the exception of a small amount of diesel fuel left by the February tractor train. Diesel fuel, lube oil, mogas, white gas, and denatured alcohol were recovered from the drop zone and cached in two areas approximately 100 and 150 feet southwest of the communications building. Drums were stowed with the bung up, and the caches were marked by trail flags. However, due to absence of knowledge of the prevailing wind, this site proved unsatisfactory. It became heavily drifted, up to 12 feet in places. Hauling fuel during the winter night was a laborous procedure involving blading with the D8 when it was operable, and digging by hand at other times. The D8 boom was used to haul drums to the tunnel mouth by means of barrel chimes. The drums were then manhandled and arranged along the tunnel sides. From this location diesel fuel was hand pumped into jerry cans for daily refueling of each building.

Due to contamination with rust and water, utilization was approximately 50 gallons per drum. Base diesel consumption, exclusive of D8 tractor operation, varied between 70 and 90 gallons per day, depending upon wind and temperature. In the later months of the year, drifts up to roof level afforded insulation with a preceptable decrease in heater operation. This insulation also diminished the 40 to 50 F temperature gradient between the deck and the overhead.

POL recovered in the November 1957 airdrops was cached by type about 450 feet due east of the base. The pallet pack was retained for easier hauling. The old cache was emptied in November when the tractor train and the traverse party were fueled and the remainder pumped into the drums lining the tunnel. A Barnes 50-gpm fuel pump, recently found and used in this last operation, made easy the transfer of fuel from the cache to the station. Enough hose was available to pump direct from cache to tunnel. With additional hose lengths, direct pumping from the new cache would eliminate much of the strenuous effort previously required.

The Barnes pump was also used for the refueling of aircraft. For this operation avgas was towed to the area on a 20-ton sled, and the pump was mounted on a 1-ton sled behind the weasel.

South Pole

All POL airdropped after mid-December 1956 was in 4-barrel harnesses, mainly with ribbon chutes. The barrels landed hard, burying themselves to nearly their full height. They were recovered, two harnesses at a time, with the D2 and dragged into camp. The drums were rolled into the tunnels by hand and stacked by hand. They were stacked horizontally, and as one row was completed plywood was laid on top

of it so that the next tier of drums could be rolled onto it. All POL was stored inside the tunnels or in caches. Some 40 drums of diesel and 19 of mogas were cached alongside the emergency Jamesway. Mogas was also stored next to the inflation shelter.

Initially, fueling was done by 5-gallon cans, filled from drums in the tunnels. When tunnel temperatures dropped to -60 F, however, the adding of cold fuel to the stove tanks caused icing which fouled fuel lines and carburators. Thereafter, the drums were brought inside to warm up before use. Later, drums were placed in the science building and barracks and were periodically refilled using a 24-volt aircraft fuel transfer pump run off batteries. The same pump was used to pump fuel up to the tank in the Aurora Tower. Fuel usage averaged about two barrels per day, one for the generators and one for heating.

Hallett

The POL products for Hallett Station were off-loaded from the USS ARNEB directly to a permanent storage area and were stacked in parallel rows three drums high. This location, approximately 150 feet east of the main camp, provided easy access and maximum safety in respect to fire hazard. The fuel consumption for Hallett Station was not considered excessive, and the supply provided was adequate. No excessive quantities of lube oil were expended. A sufficient quantity of antifreeze was provided, but some loss was caused by barrels rusting. When evidence of leaking was discovered, the remaining quantity of antifreeze was transferred to better containers.

Wilkes

POL was situated in three separate areas at Wilkes Station. The main storage area was located near both the ice ramp, for ease in off-loading, and the main station for usage. This area contained diesel fuel, lubricating oil, antifreeze, white gasoline, alcohol, hydraulic oil, and greases. The location was excellent from the standpoint of usage but close enough to the station to be a fire hazard. The communications building with its transmitting antennas was within 50 feet of this dump. In the future fuel dumps should be located a safe distance from radio transmitting equipment. Another storage area for gasoline, both white and automotive, was located about 500 feet from the main camp. An emergency fuel dump containing adequate POL for a year of survival in the temporary (survival) camp was located about 1000 feet from the main camp. The initial supply of POL was adequate for three years operation with the exception of some minor items.

Diesel and gasoline fuels were found badly contaminated with water and dirt. Strainers and filters should be incorporated in all fuel pumps used on this type of operation. Gasoline and diesel fuel were pumped into vehicles by means of a hand operated rotary pump which proved adequate for the job. Diesel fuel for the generators and stoves was transported from the dump into the camp in the tractor scoop. Fuel was then transferred into the tanks by means of the rotary hand pump. This operation was tiring, time consuming, and inefficient. Efforts to fabricate a satisfactory fuel pump from materials available were unsuccessful. It is recommended that a suitable, safe electric motor or engine driven pump be furnished for fuel transfer.

Ellsworth

All POL was received in drums and was placed in a supply depot. D4 tractors equipped with boom and barrel chimes were used to handle the many thousands of barrels. Fuel was later cached in the tunnels.

Section X

TRANSPORTATION EQUIPMENT

WEASEL (M29C)

McMurdo

Although unsatisfactory in many respects, this type of machine was indispensable as a personnel carrier. No other vehicle solved the problem of transportation over ice, snow, rock and mountain as did this machine.

A total of nine weasels, bought from the Army, were delivered to McMurdo for Deep Freeze I. "All had been reconditioned at Davisville and gave excellent service in the antarctic."[8] Pontoons were removed to reduce the weight of the vehicles and to allow more units to be stored in the garage. Several were modified as pickup vehicles. Several were modified by removing the tops for greater safety on the ice.

When the 1956-57 summer season commenced, all the original weasels were worn out. Four "new" weasels were delivered in late October 1956. In December four more were flown in and three were delivered by ship. All of these machines received extremely hard use and were badly worn by the time Detachment One departed Antarctica. Probably the most arduous service performed by them was during the offloading of AvGas. Each weasel pulled three one-ton sleds loaded with four-inch hose.

The most serious troubles were with the transmissions and tracks. Transmissions furnished in 1956 were "standard" as opposed to "heavy-duty." These standard transmissions were not nearly so durable. Second gear went out almost at once on virtually all machines.

The tracks originally received were underdesigned. In addition they had apparently been in storage a long time and the rubber around the cables was cracked and the cables were badly corroded. Sometimes only one strand would be sound. Tracks received as replacements just prior to Detachment One's departure were substantially better. The original tracks had only a single supporting cable in the perimeter of the tracks; on the new ones this was doubled. Since it was at this point the breakage usually commenced, substantial improvement should result.

The water connection to the hot-start heaters from the gasoline heater continually broke off. The mounting was inadequate. The mounting of the personnel heaters was not satisfactory. Ether starting was not effective. "Type 939 engine heaters were installed in bilges and leaked all the time. The gas tank for the heater was outside. The filter froze and broke, and the fuel line broke from being stepped on."[7]

The AN/GRC-9 radios installed in the weasels were never very successful. They gave excellent service for a short period, but the vibration of the weasel quickly rendered them inoperative.

Recommendations

That personnel carriers procured in the future for McMurdo contain these features:

1. Lightweight (less than a weasel 5400 pounds).

2. Heavy-duty dual-range transmission.

3. Governor to limit speed to 15 mph.

4. Rugged easily replaced tracks, suitable for use over rock and ice as well as snow. It would be very desirable to have tracks which could be easily spliced.

5. Ready escape features.

6. Permanent anti-freeze, and thermostats with settings of 160 to 175 degrees.

Little America

Deep Freeze proved the weasel to be a highly versatile antarctic vehicle. Weasels were the primary means of personnel transportation and were also used with the crevasse detector and aircraft crew sled. Running boards were fabricated on weasels at Little America V during Deep Freeze I and were considered desirable not only for convenience but also as a safety factor. Maximum mileage on any vehicle was 4510 miles with one engine change. The minimum mileage was 3372 without engine change. They had to have new tracks, new drive wheels and bogie wheels installed after about a month of operation.

Engine and Engine Winterization

The engine performed satisfactorily, requiring normal maintenance. The 939A South Wind engine coolant heater performed satisfactorily,

preheating the engine with 9170 motor oil in crankcase to -20 F. Additional heat was required at colder temperatures or if high winds were prevailing. The engine oil was changed to sub-zero type when the temperatures were below -20 F. The engine coolant heater performed satisfactorily to -50 F with no winds; at colder temperatures additional heat was required. Kim Hotstarts were unsatisfactory and not considered necessary. The 1030C personnel heater performed satisfactorily, requiring but minor maintenance. Ether primers were not used on weasels. During Deep Freeze II it was felt that at all temperatures below +5 F, the engine should be preheated until the oil runs freely off the dipstick. In all cases the Herman Nelson heater was used. Without preheating, it was found that the shaft from the distributor to the oil pump had a tendency to shear off. The engine as installed is most difficult to work on; even a normally simple task such as changing a fan belt takes a major effort because of confining space. Standard size engines only should be sent to the polar regions, with only standard size replacement parts. Many oversize and undersize spare parts had been sent.

Cab Winterization

The cab was quite satisfactory, but the hatches should be more securely attached; latches broke loose and hatches started to drop and would not latch.

Clutch, Transmission and Chassis

The clutch and chassis were satisfactory, requiring only normal maintenance. Heavy duty transmissions were installed in all Deep Freeze I weasels. However, several transmission failures occurred. Front bearing failures on the mainshaft were the source of transmission trouble. GOS was used in all transmissions. During Deep Freeze II some trouble was encountered when clutch plates became glazed. Because of the continued rough usage, a heavy-duty transmission is recommended.

Fuel, Ignition and Electric Systems

The fuel and ignition systems were satisfactory. The radio interference-suppression equipment made the ignition system hard to work on. Ignition coil failure was high. A better lighting system should be installed with at least two headlights forward.

Tracks and Track Carriers

Track replacement on Deep Freeze I was high. The tracks had been stored in open storage for a long time and the rubber had deteriorated. Track failures increased at -40 F and below. During Deep Freeze II the track cables broke, not the pads. By greasing all running gear once a week, bogie wheel wear was negligible. Of the 480 spare bogie wheels with Deep Freeze II, six were used.

At speeds of no greater than ten miles per hour there was maximum utilization of tracks. It is recommended that all tracks be of the heavy-duty type and that speed limits be enforced. It was found that temperatures below -40 F caused brittleness in the tracks and breakage increased considerably. For this reason weasel operation was curtailed at -40 F and below. However, if the weasel is stored in a warm place, it could be and was used in extremely low temperatures.

Maintenance

Normal preventive maintenance and repairs were required.

POL Products

Cooling system - premixed permanent-type antifreeze

Engine oil - 9170 and sub-zero (MIL-0-10205)

Transmission and differential - GOS (MIL-L-10324)

Gasoline - arctic type C (MIL-G-3056)

Grease - MIL-G-10924

South Pole

The M29C weasel was airdropped from a C-124. Prior to delivery, both front and rear pontoons were removed. The personnel heater mounted on the rear pontoon was modified to mount on the rear left portion of the roof. A spreader bar type of pipe frame was fabricated from 1-1/4-inch pipe and mounted around the top of the cab to prevent it from being squashed and the parachute risers from being cut on any sharp metal. An AN/GRC-9 radio was installed.

For the airdrop the entire unit was strapped to a drop platform made of aluminum and steel and was supported entirely on shock pads to prevent breakage due to impact. The weasel hit very hard when it dropped and (unknown at the time) the transmission case was cracked. The failure was believed to be due to the impact on the unsupported drive shaft. It is recommended that future weasel drops incorporate complete support for the drive shaft and transmission; otherwise the drive shaft should be disconnected.

The transmission was a light-duty unit which caused difficulty throughout Deep Freeze I and II. The weasel performed satisfactorily

at the high altitude during Deep Freeze I, II and III, although a definite power loss was observed. Special jets for the carburetor were not available. Operation was almost exclusively in low range, as the rough sastrugi negated high speeds. A few problems were experienced during Deep Freeze II. The rubber covering the track cables cracked completely through about every inch or two, and on one track all but one or two cables were found to be broken, perhaps a result of operation in extreme cold. A new starter assembly had to be installed. Routine preventive maintenance was carried out regularly.

Recommendations

1. Provide heavy-duty transmissions and tracks.

2. Investigate the possibility of installing a supercharger.

3. Remodel the cab for greater utility and passenger/cargo capacity and for greater ease of entry and exit.

4. Provide a top rail for cargo-carrying purposes.

5. Pole Station weasels should all be equipped with radios. A dynamotor should be mounted behind rear seats.

Byrd

This vehicle had been operated for only a month when the left track and the left rear bogie support shaft broke. Since there were no parts available to fix it, the weasel was stored until the arrival of repair parts.

Hallett

No particular problems that could be attributed to cold-weather operations were found in this equipment.

Recommendations

1. Enlarge the doors if possible to allow easier entry and exit for personnel dressed in heavy clothing.

2. Adjust the engine covers to allow easier accessibility to the engine for maintenance.

Wilkes

The design of the M29C cargo carrier is fundamentally very sound for the uses to which it was put at Wilkes Station. However, some problems were encountered.

Tracks and Track Carriers

Early in the year all of the original tracks broke. The heavy-duty replacement tracks went the rest of the year with only one more failure and this was on a track that appeared much older than the others. Several track drive sprocket failures occurred but these also did not recur after the heavier replacement sprockets had been installed.

Engine and Engine Winterization

The most serious problem was the persistent failure of fan and generator belts. Since the replacement of belts is a rather difficult operation to perform in the field, it is believed that either a chain or a gear drive should be used.

The gasoline-burning engine heater unit did not operate very well in one unit. The M29C used in digging the glaciological deep pit surprisingly started regularly in temperatures down to -50 F. The batteries in the M29C were given an assist during starting by using a battery charger as a booster.

Clutch, Transmission and Chassis

The transmissions and clutches simply wore out under operational loads that were apparently more than they were designed for. The M29C's were used repeatedly in hauling fully loaded one-ton sleds up to the icecap station, which is probably responsible for a large part of the wear. Although a heavier design would extend the life of these components it is believed that merely assuring that adequate spares are provided would be satisfactory, as these parts usually show signs of wear before they fail. The springs, however, would have to be strengthened to make the vehicle more reliable. The spring failures exhibited some of the characteristics of fatigue failures.

The bodies were not very durable and the doors in particular were not strong enough to last very long. The bodies were also far from snow-tight and the inside often filled with snow during storms. The use of some type of rugged, flexible cover for the vehicle would probably eliminate the problem.

Ellsworth

The weasels turned in an excellent performance and were most useful for towing one-ton sleds and for general light work.

Recommendations

1. Extend the driver's access door to include a small portion of the roof. The small step provided for driver access should be enlarged and of treaded material.

2. Mount radios facing inboard for easy operation by driver or passengers.

3. Raise driver's seat four inches to give better visibility of the trail.

4. Provide larger offsets in the clutch levers to give more foot room for antarctic footgear.

5. Provide a separate fuel pump, cut in electrically, for the personnel heater to keep gasoline pressure off the heater fuel system except when in use.

SNO-CAT

McMurdo

The Sno-Cats brought in by the Air Force lasted only a few days, as the dirt quickly abraided critical track parts. No Navy Sno-Cats were allocated to McMurdo during Deep Freeze I.

Little America

Two model 743 Tucker Sno-Cats were used at Little America on Operation Deep Freeze I and II and were considered excellent snow vehicles. They were used primarily as personnel carriers between Kiel Field and the main camp. "The Tucker Sno-Cats were very satisfactory in regard to pulling ability and riding comfort, except for the side-to-side movement."[8]

Engine and Engine Winterization

Engine performance was satisfactory, but indications are that less horsepower is required. Some trouble was encountered with engine vibration, which caused the exhaust stack section to uncouple at the elbow going through the engine compartment so that toxic fumes entered the cab.

Heated battery boxes are a necessity in this type of operation. The battery box should be redesigned for more sturdy support, or it should be relocated.

The performance of the 939A South Wind engine coolant heater was satisfactory and required a very limited amount of maintenance. However, at temperatures of -30 F, with 9170 motor oil in the crankcase, the 939A coolant heater would not heat the engine to starting temperatures. Shrouding, or some method should be devised to use waste exhaust heat to preheat the oil. At operating temperatures, sub-zero motor oil, MIL-O-10295, appeared to be too light for proper lubrication, thus 9170 motor oil was used in the crankcase. Quick heat from a Herman Nelson BT400 series heater was required to bring the motor oil to starting temperatures below -30 F. Quick disconnects for use with the vapor car heater to preheat the engine coolant proved satisfactory. To maintain operating temperatures a canvas winter front was used. We recommend that a manual-controlled shutter-type winter front be used. The engine compartment should be enclosed because of carburetor icing at extremely low temperatures, and it would be desirable to design a method to apply heat to the carburetor. "A Kim Hotstart is not necessary."[9]

"For the approximately 900 miles traveled on the trail, the engines appeared to be in very good condition and the oil consumption was negligible. Gas consumption was 1.3 miles per gallon while pulling approximately a 3-ton load at 10 miles per hour in 5th gear."[8]

Cab Winterization

A 1030C South Wind personnel heater was used to heat the cab. The heater proved satisfactory, with a minimum amount of repairs. A more equal distribution of heat could be achieved by manifolding the output adapter to distribute the heat aft. The defrosting system should be revised to force the heat on the glass from the bottom, and the cab should be completely insulated.

Cab Structure

The cab is quite flimsily constructed and should have a more substantial latching device on front doors to keep them from coming open while traveling over sastrugi and rough terrain.

It would be desirable to have windows that may be opened, at least in the driver's compartment, and, with the exception of the front door, side windows of one-piece glass or other suitable material. Rear view mirrors are desirable.

Clutch, Transmission and Chassis

The clutch and transmission were satisfactory. The chassis should be reinforced throughout, especially around the dead end of the hydraulic steering booster cylinder, which broke continually at this point. It

is believed that a synchro-mesh transmission would be desirable. Thus, operation would be easier and there would be less chance of damaging the gears.

It is recommended that a suitable sled hitch be installed on the rear of the chassis to facilitate use of the towbar for moving one-ton sleds. A practical one was fabricated and installed at Davisville, Rhode Island, and proved to be very satisfactory. One rear differential failure was experienced on one of the units which may have been caused by metal breakdown in extreme cold.

Fuel System

The fuel system was very satisfactory. Gasoline consumption varied from three-quarters of a mile to three miles per gallon, depending on the type of operation. "Difficulty was encountered with the fuel pumps. The trouble was caused by aluminum filings left in the tanks after drilling them for fittings."[8]

Electrical and Ignition Systems

Very satisfactory. "The electrical system used a positive ground; consequently the AN/GRC-9 radios could not be installed."[8]

Hydraulic System

Heavier pump drive belts are recommended because of excessive belt breakage. This was caused primarily by snow building up on pump pulleys, which could possibly be eliminated by engine compartment enclosure. Also, it is felt that some belt breakage may be due to thick fluid and/or extremely low temperatures. The fan belts should be improved. The hydraulic steering was a source of some trouble during Deep Freeze II and should be strengthened. It is recommended that breakdown parts be furnished for the hydraulic system as well as complete assemblies.

Tracks and Rollers

Excessive track roller failures were encountered at the beginning of Deep Freeze I. The causes are believed to be: (1) constant exposure to salt water and spray on board ship, as both units were deck cargo, and (2) a need for more frequent lubrication than every 200 miles as specified by the manufacturer's service manual. "Should use sealed bearings, since moisture penetration causes flattening of bearings."[9] Arctic-type grease lubrication should be performed every 50 miles. During summer months, ball and roller bearing grease was used and proved to be very satisfactory. This type of grease is too heavy for use in winter.

All roller failures were in the ball bearings. During the period of roller failures, excessive connecting-link failures were encountered. It is believed that the roller bearing seizures caused link failures. More frequent lubrication would practically eliminate roller failures.

Nuts on the rollers had to be checked and torqued with each lubrication. The bottom roller guide on the pontoon showed considerable wear. It is recommended that material be furnished to replace this rail. Four failures on pontoon outer bearings were believed to be caused by the nut working loose and shearing off the cotter pin and allowing the bearing adjusting nut to work loose. The Tucker Sno-Cat representative stated that a heavy-duty roller has been designed and is available.

Maintenance

Normal maintenance was required after the roller failures were corrected.

Recommendations

During Deep Freeze I it was found that:

1. Spare transmission, clutch, pressure plate, throw-out bearings, transfer case assembly and breakdown spare parts should be provided.

2. The Model 443 Sno-Cats should be considered as a personnel carrier in lieu of M29C weasels.

3. Lifting pads should be installed to facilitate loading and off-loading.

4. Two side plates and straight bolts and nuts should be used to eliminate weld failures in the track.

5. The hydraulic pump for power steering should be mounted closer to the engine and be better housed for protection against snow. Also, a gear-driven system would be better than the belt-driven.

6. The towing hitch, which was installed at Davisville, should be mounted so that strain is evenly distributed.

During Deep Freeze II it was found that:

1. The frame was too light in construction and allowed contortion. A substantial longitudinal frame should be used with adequate means for securing the body to the frame.

2. The fifth wheels which are of cast aluminum, were fractured on two occasions. It is thought that a comparable fifth wheel of steel would lessen the possibility of breakage.

3. A ceramic filter should be installed on the gas line, just ahead of the carburetor.

SNO-KITTEN

Though not of value for heavy hauling, the unit proved to be of great value at the Beardmore camp, where support was limited. It was used there to haul parachuted material into camp, as a personnel carrier, and to pull a drag on the ski landing strip.

ONTOS

McMurdo

This unit was received at McMurdo on an experimental basis and proved to have an excellent suspension system and power train. Its main drawback was excessive weight, which makes it impractical for deep snow work. The body is not designed for easy access for the transport of personnel. "The Ontos is mechanically outstanding. . .and has definite potential if the body were lightened."[5]

Little America

"The Ontos was of no value at Little America because of its penetration in the snow. It apparently lacked sufficient track surface and was too heavy for the snow in this area."[8]

SLEDS

20-Ton Sleds

McMurdo

The 20-ton Otaco bob sled proved to be the best ice-and-snow sled available to Deep Freeze I forces at McMurdo. The only modification made was to put pins through the frame to prevent the frame from separating from the platform. Ten-ton sleds were ordered for Deep Freeze II in order to reduce the total load on the sea ice. "One sled could hold between 80 and 90 drums of fuel and a D8 could pull it. The only trouble was with the pin holding the towbar. This was welded and the trouble was ended. The rear wooden stake rack should be replaced with steel gates to prevent breakage when the sled is towed up a grade and the pressure of the load is on the tailgate. Every sled should have its own tailor-made cargo net to save much time now spent lashing the cargo."[7]

Little America

Thirty-eight of the OL553A 20-ton Otaco bob sleds were used. These sleds were designed for heavy tractor train hauling and were towed by low-ground-pressure Caterpillar D8 tractors. The total weight of the sled is 21,827 pounds. It's hauling capacity is rated at 20 tons; however, loads up to 25 tons were frequently hauled. The 20-ton sled was used predominately during Deep Freeze II. Difficulties were:

1. The sled beds were continually leaving the bunk assembly when traveling over uneven terrain. A chain was welded to the sled bed and hung loosely under the bunk assembly. This allowed movement, but not to the extent of permitting the bed to leave the bunk.

2. The chain failures occurred under heavy stresses when breaking sleds loose from snow during the tractor train operation.

3. Six draw-pole sub-assemblies broke approximately 24 inches from the end of the draw poles while breaking the sleds loose from burial in the snow.

4. Two bunk assembly studs broke. Failure was believed to be caused by crystallization of the studs in extremely cold temperatures.

5. Half way through Deep Freeze II it was discovered that all 20-ton sleds had been assembled backwards. In other words, the wide bunk pocket rested on the rear set of runners rather than over the front set. Sled handling ease was increased greatly when the sled beds were turned 180 degrees. Fewer chains parted and there was much less chance of causing damage to kingpins.

6. Stake breakage was excessive, though perhaps rough usage was a large factor in the damage. The hardwood uprights became extremely brittle and broke too easily. A steel or steel-reinforced upright should remedy the situation.

In general, the overall design, construction and performance of the sleds was very good. It is recommended that during heavy swing operations, extra sled chains be taken.

10-Ton Sleds

McMurdo

The Go-Devil sleds were good but the towing tongue was improperly fabricated. The eyes of the tongue were so snug on the pin that they soon cracked off because of inadequate clearance for vertical movement of the tongue. "Due to the design of the runners, the sled would not track. The payload was 20 drums and a D2 could pull two sleds."[7]

Little America

The 10-ton sleds were used to a limited extent at Little America during Deep Freeze II. However, during the ship off-loading, every available sled was employed. During the rest of the year the 10-tonners were used for collecting and hauling trash and for storing easily lost items above the snow. The following shortcomings were noted:

1. The wooden bed was easily damaged by heavy cargos.

2. The stakes had the same weakness as the 20-ton sleds.

3. The bunk stop brackets need reinforcing, as they shear off under normal use.

4. Because of the nonrigid nature of the kingpin assembly, the sleds cannot be backed down without danger. It is necessary when backing loaded sleds while getting underway to break one set of runners loose at a time.

5. "The bob sled with a tank trailer attached was hard to handle due to the narrow runners. LGP runners should be used on a sled of this type and capacity when intended for use at Little America."[8]

6. "The angle-iron bracing welded to the underside of the bed broke off. This was either a defective weld or the weld was not heavy enough."[8]

7. "Difficulty was encountered in hooking one sled behind the other. This was due to the lack of a means of lifting and aligning the drawpole of the rear sled with the pintle on the rear of the front sled."[8]

A feasibility test using a D8 to tow five 10-ton Otaco sleds loaded with POL, was conducted at Little America. The test was conducted with 40 drums of fuel on each sled. The D8 attempted to break the runners loose from the snow by backing down. As pressure increased, the front bench assembly of the front sled rolled under the bunk, bending the kingpin. The D8 then pulled ahead and the left pole chain of the forward sled snapped and the nose casting pulled off the drawpole. The drawpole was reinserted, the chain was repaired, and the runners were broken loose by side nudges of a D4. Another D4 pushed the rear of the last sled while the D8 pulled. This simultaneous push-pull was successful in getting under way. The sleds towed easily in second gear and were halted after a quarter of a mile. The measured clearance of the last sled was 36 inches. The temperature was -55 F. When the tractor was shifted to third gear and a towing force was gradually applied, both pole chains on the forward sled snapped. Test evaluation; Tow not feasible for starts and stops, unless chains are strengthened and the bunk-bench assembly is modified to permit backing down.

Toboggans

McMurdo

The toboggans and the deep-runner toboggans created too much friction because of the great area in contact with the snow-covered ice. The angle runners of the former sleds cut into bare ice and prevented turning. These sleds are not satisfactory. "The payload with a D2 was about 20 drums of fuel. The D2 could pull only one at a time."[7]

Recommendation. "Lengthen the shaft of the towing spider one foot on both toboggans, as the chain stretches and allows the present short shafts of the spider to slip from the tongue."[22]

Little America

"Believe low attachment of towing hitch destroys bow profile necessary to prevent snowplow action. Suggest you model one toboggan for trial as follows:

1. Remove towing eye assemblies.

2. Remove plate MK-45 from assemblies.

3. Cut braces MK-48 to bow curvature from 1/4 inch below highest point in elevation view to meet lower right corner in elevation view.

4. Reassemble towing eye assembly and remount on toboggan with weld or bolts, with forward edge of MK-45 plate flush with front face of MK-3, reinforcing plate MK-46 in same relative position as before. See NCEL drawings E55-50, E55-51, 56-30-1F".[27]

One-Ton Sled

McMurdo

The one-ton Army sleds proved useful on all occasions. "The support under the bed forms a trap for drifting snow. The weight of the snow reduces the payload and removal of the snow is difficult."[7]

South Pole

Two one-ton Army sleds were airdropped along with the weasel. Both served well in retrieving equipment and in hauling gear throughout the camp.

ATHEY WAGONS

The tracked Athey wagons were useful on the snow and gravel surfaces at McMurdo.

2-1/2-TON CARGO TRUCKS

The two 2-1/2-ton trucks with jungle tracks, which arrived at McMurdo in October 1957, were worth their weight in gold. They handled the transportation to and from the runway.

WANIGANS

Little America

Two messing and three sleeping wanigans were delivered during Deep Freeze I for use on trail operations to Byrd Station during Deep Freeze II. Several problems were encountered:

1. Before the sled beds were assembled correctly, much "working" of the wanigans took place. The rigid panels have no inherent give, thus the joints are sources of trouble. Connecting bolts sheared off constantly. Interior partitions likewise were battered and shattered as the flexible sled bed undulated with the terrain. It is thought that construction along the lines of a house trailer would make allowances for such distortions and would eliminate flexural damage.

2. Five-kw gasoline engine-driven generators were substituted for the diesel generators provided. Much more satisfactory results were obtained.

3. Communications being so important, a radio of the following characteristics should be employed: small, compact, with high output/input ratio.

Byrd

Difficulty with the messing wanigan was experienced from the movement of the panels; however, the range, sink, etc., worked satisfactorily.

It is suggested that the following be considered during heavy swing operations:

1. That a platform 18 inches wide be constructed along the rear of the wanigan to provide a footpath for the cook between the rear door and the racks on the sides of the wanigan.

2. That the 5-kw generator be relocated in the wanigan or be shielded to prevent noise.

Section XI

PRIME MOVERS

GENERAL COMMENTS

Winterization of a tractor cab meant very little to the men working on the sea ice at McMurdo. They would rather be cold and have ready access to the wide open spaces by keeping both doors open and the escape hatch off. Warmth was desirable, but safety was more desirable. On new sea ice where the thickness was less than 7 to 8 feet under the best conditions, there was always doubt as to the strength.

Low-ground-pressure equipment is not suitable for stations located on hard soil or ice, but is ideal for stations located on heavy snow. Standard equipment is best suited structurally to do the heavy work on hand for McMurdo, Hallett and Wilkes stations.

Deep Freeze II forces at McMurdo felt that heated battery boxes were not necessary. With electrical systems in good working order, there was no trouble in starting the tractors. Engine side panels were considered to be more trouble than good. In snowstorms the entire engine would be packed with snow and would have to be dug out before starting. However, if engine side panels are removed, the snow blows free of the tractor engine. Conversely, under the condition of wind-blown snow, such as experienced at Little America, the engine side panels were not fitted tight enough. Snow seeping into the engine compartment increased the difficulties already presented by the low temperatures.

D2 TRACTOR

Eight Caterpillar D2 low-ground-pressure tractors were assigned to McMurdo. One was used at Little America V during Deep Freeze I, II and III. It had a blade attachment, D315 engine, Model 44 hydraulic control, snow sprockets, and 42-inch grousers. This tractor was considered very useful for camp maintenance and for positioning sleds on the bay ice alongside the ships during off-loading operations. It was also a very good machine for moving aircraft on snow. But it was too light for the heavy work at McMurdo. Except for camp detail work, any of the tasks requiring tractors imposed too great a strain on the D2, resulting in

failures. As they were the only items in large number in Deep Freeze I, they had to be utilized. A D2 could just barely pull a 20-ton sled loaded with 14 tons on smooth ice. Any drift was sufficient to stop them, as the tractors quickly buried themselves. Once three of the D2's were mired in the snow at the same time trying to get one sled through a drift. A D4 was brought to the scene and easily freed the entire works.

A D2 was air-dropped at the South Pole at the beginning of Deep Freeze II. For the drop the following were removed: the blade and trunions, the LGP pads (the chain was left on), the counterweight and the cab. The LGP pads were replaced with 12-inch pads. This allowed the tractor to be moved around on the drop platform. Two extra chains fitted with LGP pads were taken along. When the tractor was dropped, it was driven off the 12-inch pads and chains onto the chains with the LGP pads. Thus in a very short time the tractor was operative. The D315 engine was not supercharged, so that it was diminished in power at the 9400-foot altitude. A supercharger would be desirable. The oversized engine, however, performed satisfactorily to drive the lightened tractor. The LGP pads were excellent and necessary in the deep, soft snow.

Sustained outside operation was not considered feasible at the Pole at temperatures below -50 F. By keeping the D2 in the garage it was possible to use it for brief periods at nearly all temperatures. The most evident sign of the effect of cold was stiffening of the track chains, and when this occurred the tractor was run back into the garage to thaw out.

Engine and Engine Winterization

Engine operation was satisfactory. 9170 motor oil was used in the crankcase at temperatures above -20 F. "For maintenance purposes, it would help if the oil filter pipes were about 6 inches longer."[8] One engine breakdown was experienced; this was due to oil-pump failure in which the shear pin was broken on the drive gear. It is believed that this trouble was caused by insufficient preheating. Failures of this type required repairs that were time-consuming, as the rock guard, transverse spring and oil pan had to be removed.

Quick disconnects to the engine collant system were satisfactory. The heated battery box proved to be satisfactory at Little America. However, at McMurdo the battery boxes had to be rebuilt several times. They were entirely too flimsy to stand up under the vibration experienced in over-the-ice work. The copper tubing circulating warm coolant required constant maintenance. The circulating pump should be relocated.

Deep Freeze I and II suggested relocation of batteries outside the cab to give the operator more room and to permit better access to the clutch inspection plate. Removable supports for batteries are recommended

to hold batteries up off of the heating coils, as the weight of the batteries and the vibration create leaks in the coils. A more substantial support is recommended for heating coils to prevent them from working down in the insulation and chafing against the inlet and outlet holes in the battery box. Conduit clamps were installed to hold the battery leads in position. A battery box thermostat to control the circulating pump is considered essential.

Kim Hotstarts were not satisfactory at Little America, as heat transfer was not sufficient to preheat the coolant. The 939A South Wind coolant heater was satisfactory with subzero motor oil in the crankcase to temperatures as low as -50 F and no wind. However, exhaust from the heater should be shrouded around the oil pan instead of into the open rock guard. Only routine maintenance was required on the entire winterization kit.

Ether starting was not required at Little America provided the engine was properly preheated. In all cases of starting the engine with temperatures below -50 F and no wind, quick heat was used to augment winterization for preheating as well as for melting snow from the engine compartment. The compartment has a tendency to fill with blowing snow and precautions should be taken to melt the snow from around the fan belts and pulleys. Preheating was accomplished in the process of melting snow from the compartment engine. The ether priming system was not effective at McMurdo, as the discharge lines froze up at relatively warm temperatures (-20 F). It is also hazardous to use if it is not working properly. Radiator fronts of canvas were made to keep the engine up to temperature.

Starting Engine

The starting engine was very satisfactory and only routine maintenance was required. Subzero oil was used in the crankcase. The ignition system was quite satisfactory.

Cab Winterization

The South Wind 1030C personnel heater should be mounted more sturdily. Excessive vibration of the cab continually broke mounting brackets. The heater should be shock-mounted. It is also recommended (1) that a manifold with ducts be installed on the air outlet adapter for a more equal distribution of heat throughout the cab; (2) that defrosters be installed in both front and rear windows and that they blow from the bottom of the glass upward; (3) that the heater exhaust be extended so as to direct the exhaust away from the cab glass and the rubber molding around glasses; and (4) that a filter be supplied for the heater fuel system.

Cab Structure

The structure of the D2 cab was similar to the D4 cab. The supporting structure, however, was not considered as satisfactory at McMurdo. The two fenders on which the cab rested were tied together by the fuel tank; consequently, as the fenders spread and settled under the load and vibration, leaks formed in the tanks. The tank bottoms were replaced by 1/4-inch boiler plate and a 2-inch angle iron was also used to prevent the fenders from spreading. During movement the body had a tendency to slide and strike the chassis.

The cab seemed to be very satisfactory and necessary at Little America V. Insulation was satisfactory. It is felt, however, that insulation mats should be formed around all inspection covers to make them accessible without breaking the insulation, which becomes very brittle at low temperatures. Trouble was experienced with sheet-metal screws working loose in the overhead. Also, it is felt that the escape hatch should be redesigned to insure an easier and quicker releasing system.

Clutch, Transmission and Chassis

The clutch was very satisfactory and only routine maintenance was required. During Deep Freeze II the clutch gave some trouble, as the bronze yoke wore. The transmission was satisfactory and only routine maintenance was required. Gear Oil Special was used in the transmission and the bevel gear compartment. "Difficulty was encountered with the oil clutch due to the undersize rod restricting the flow of oil to the clutch."[8]

Only minor troubles were encountered with steering clutches and brakes. Fuel tank leakage through the brake inspection plate and into the steering clutch compartment necessitated the disassembly of the clutches and brake to remove diesel-soaked discs and bands. The diesel oil removal was done by heat and alcohol. Final drives were satisfactory. GOS was used. Sprocket wear was considered normal. The chassis was satisfactory. Routine maintenance was required.

Fuel System

It is recommended that the diesel fuel tank be mounted on shock-absorbing material to prevent undue ruptures in the tank caused by excessive vibration. The fuel tank cap should be anchored to the tank to prevent loss. Normal maintenance was required on the fuel pump, filter housing and fuel filters. No engine failures due to ice in the fuel system were encountered. Denatured alcohol, grade 3, was added to the fuel periodically, approximately one quart per hundred gallons of diesel fuel.

Electric System

The electric system was very satisfactory. Only one voltage regulator failure was reported by Little America. However, at McMurdo all regulators failed shortly after installation. The battery lead terminal clamps had a tendency to come loose due to vibration, causing short circuits and batteries to blow up. All terminal clamps were the quick-disconnect type. It is recommended that standard bolt-type clamps be used. An electric cable with more flexibility at low temperatures would be desirable. The stiffness of the cable used had a tendency to loosen the battery posts due to vibration. "Filters on the RIS developed internal shorts."[9]

Hydraulic Systems

The hydraulic control for the blade was very sensitive and fast. It is believed to have a D4 hydraulic pump in the system. Considerable hydraulic hose failure was experienced in extreme cold weather. The hose would harden, crack, and lose hydraulic fluid. This was rectified by use of prefabricated hose fittings and aircraft-type hydraulic hose No. 16.

Drawbar

It is recommended that the drawbar be made more accessible for insertion of the drawbar pin when the machine is equipped with a winch. "An improved type of holding pin would improve the present locking method."[9]

Winch

The winch was satisfactory. Gear Oil Special was used as a lubricant. One winch failure was experienced due to negligence; the winch was engaged with load and the tractor was moved under load. "The locking device slips on the winch controls. Deep Freeze II found the winch sensitive to the point of being dangerous."[9]

Tracks

Considerable difficulties were encountered during Deep Freeze I and II with track bolts shearing off and track links breaking. The cause of the breakage on both items is believed to have been caused by the oversized pad used with the standard bolts and links. To increase the diameter of the track bolts would necessitate a heavier track rail. Conclusions are that a heavier undercarriage should be used throughout. Track bolt breakage was reduced considerably by operating the machine in third speed and below. At McMurdo, most of the pads were cut down from 42 to 24 inches. Loss of master pins was excessive. The master track

pin plug would work out and in turn the master pin sleeve would work out and break due to bending of the grousers caused by their excessive length. This trouble was reduced at Little America by operating the machine in the first three gears. McMurdo replaced them with special pins machined from meridian steel. Track frames in every D2 cracked forward of the trunion. "Frames were welded and reinforced with gussets."[24] The track frame is definitely too light for the tractor, especially if the blades are used. The South Pole experienced two track chain failures. One was probably at least partly a result of cold-weather operation.

Track Carrier Blocks

Track carrier blocks were satisfactory with only normal wear. At times, however, snow would build up between the track rail and track carrier block.

Dozer Blade

The blade was of very little use at McMurdo due to track frame failure. "All D2 dozer blades were reinforced at connections of side arms and braces to blade."[24]

D4 TRACTOR

Two D4 tractors were assigned to McMurdo and Hallett. Each was equipped with bucket and fork-lift attachments. "They make a good front-end loader, but the bucket should be larger. Visibility of the forks is nil."[5] "With the fork-lift, the D4 is no good in snow; when a track is locked for steering the other track buries itself."[9]

The D4's performed in an excellent manner, not only for material-handling but also for tractor train operation, though the drawbar should be heavier. The only maintenance problem was servicing the pilot bearing of the master clutch. The master clutch throwout bearing collar (Cat Part Number 3B696 and 7B5878) required constant replacement. Because collars were scarce, they were often replaced by collars built up by brazing.

Engine and Engine Winterization

The battery box was not satisfactory, as there was excessive movement and vibration of the box and the long, overhanging fenders on which it was mounted. The box had to be rebuilt several times. The coolant heater coils were disconnected and the coolant by-passed the box. The ether priming system was not effective, as the discharge lines froze up at relatively warm temperatures (-20 F). It was also hazardous to use if not working properly.

Cab Structure

The cab structure itself was satisfactory but the supporting structure was not heavy enough to support the cab's weight. Constant maintenance was required to keep the fender bolts in place. Many sheared off. One cab was removed during the summer because of its hazard to personnel.

Tracks

The track system was ideal in that it was almost standard (the pads were several inches longer than standard D4 pads). Smooth track pads would have allowed smoother operation of the vehicle over the rocks when using the fork-lift attachment. Track pins and pad bolts caused some trouble. New track pins were fabricated from meridian steel. LGP tracks were unsatisfactory at Hallett. Standard tracks should be used there.

D8 TRACTOR

Standard-Gauge Tractor

Two D8 standard-gauge tractors were assigned to McMurdo. One was lost when it broke through the ice. The following comments apply to the remaining D8, affectionately called "Pogo". It was a superb piece of equipment and was outstanding in every respect. It expired only after almost 11,000 hours of the most rigorous use. The only failures experienced were two separate transmission failures, the second after the first had been repaired by using shop-manufactured parts and old gears that were known to have a limited life. Also, vibrations caused a failure of the hydraulic booster pump casing, which was readily welded.

The battery box had to be rebuilt several times. It was entirely too flimsy to stand up under the vibration experienced in over-the-ice work. The copper tubing circulating warm coolant required constant maintenance. The ether priming system was not effective, as discharge lines froze up at relatively warm temperatures (-20 F). It was also hazardous to use if not working properly. Radiator fronts of canvas were made to keep the engine up to temperature.

The visibility, size, and accessibility of the cab were satisfactory, although the escape hatch mechanism requires redesign. Wind blew the hatches off on several occasions. The mechanism is also very fragile and is easily broken. The fuel tank for the gasoline-operated heaters had to be relocated, as it vibrated loose from the cab.

The standard tracks were ideal for operation at McMurdo. Maintenance presented no unusual problems. Wooden track-carrier blocks were not used on this tractor.

"A boom arrangement, capable of turning 180 degrees, with a lifting capacity of approximately 5 tons, should be provided for the D8 tractors."[8] "Fuel consumption: 6 gallons per hour."[9]

Low-Ground-Pressure Tractor

These machines were used at McMurdo, Little America, Byrd and Ellsworth. They proved very satisfactory in crevasse filling, tractor train operation, ship off-loading, camp maintenance and airstrip construction.

Engine and Engine Winterization

The engines supplied with these units were highly satisfactory. Slightly above routine maintenance was observed throughout the operation. Lubrication oil and filters were changed every 240 hours of operation and 9170 engine oil was used in the main engine. One piston failure was experienced at the return of the tractor train from Marie Byrd Land to Little America. The cause was determined to be excessive water in the fuel entering the cylinder through injection. There were two push rod failures during Deep Freeze I, caused by tappet adjusting-screw lock nuts working loose and the rocker arms coming out of the socket in the push rod, thereby bending the push rod. Excessive hour-meter gear failures were encountered. This was believed to be caused by lack of lubrication at low temperatures, as oil was very viscid unless heat was applied at the accessory drive housing. One precombustion chamber failure was experienced. The cause was undetermined.

Winterization was insufficient to cover all temperature ranges encountered. However, the 939A South Wind coolant heater was satisfactory to approximately -45 F where no winds were prevailing. The exhaust from the gas-fired heater was utilized by piping it to a shroud built around the oil pan. The slave receptacles were never used. The quick disconnects for utilization of Vapor Car Heaters to preheat the engine coolant were satisfactory.

Considerable fan belt breakage was encountered during Deep Freeze I and II until the causes were found, namely snow build-up in the engine compartment around the pulley and the belt freezing to the pulley. A Herman Nelson BT 400 heater was used to melt the snow out of the compartment in and around the fan pulley.

During Deep Freeze II and II all Little America vehicles were preheated with the Herman Nelson portable aircraft-type heater by cutting a 12-inch-diameter hole in the belly-pan cover so that a heater duct could be inserted. Kim Hotstarts were unsatisfactory; the Btu output did not appear large enough for the engine. A hotstart was plugged in for 16 hours at approximately -50 F, but failed to maintain the heat present at the time of securing the piece of equipment.

Starting Engine

Arctic-type gasoline MIL-G-3506 was used. Subzero engine oil was used in the crankcase. One bearing failure on starting an engine was encountered. This was caused by insufficient lubrication oil in the crankcase due to the negligence of the operator. The starting engines were used for longer periods of time than those in domestic equipment because of the continual adverse starting conditions. Two engines completely bound up at different times during Deep Freeze II and examination showed the cause to be lack of lubrication. The subzero lubricant is not suitable for prolonged use, and 9170 engine oil was substituted with great success.

Some trouble was encountered with pinions in that the locking nut that controlled the pinion throw-out RPM worked loose, allowing the adjusting nut to tighten which increased the throw-out RPM of the pinion well above the danger point and in two cases destroyed the pinion gear. Some troubles were encountered with clutch dogs breaking; the cause was undetermined.

Some trouble with clutch brakes was experienced during Deep Freeze II. An examination showed the cause to be thick oil in the clutch housing. Application of heat eliminated this situation.

Cab Winterization

All the cabs were equipped with 1030C South Wind personnel heaters. Considerable trouble was encountered with heater bracket breakage. Frequent adjustments and repairs had to be made on the heater flame detector switch because vibration continually upset adjustments or broke the ceramic rods. A lock nut should be incorporated on the adjusting screw. The heater was installed over the clutch, which made clutch adjustment more difficult and often resulted in damage to the heater. The heater fuel control valve stuck excessively. A flexible fuel line is needed. The exhaust line of the personnel heater should be extended beyond the cab to allow locking the doors in an open position.

Because of frequent electrical difficulties with consequent loss of heaters, it was considered necessary by Deep Freeze II that a secondary heater be installed in all cabs. A fuel filter in the gas line to the heater was needed for Deep Freeze II because of the amount of water and other foreign matter found in the gasoline. All heaters should be shock-mounted.

The insulation was excellent, except that it was not fireproof and vibrations shook it loose. Insulation should be installed to permit ready access to the inspection covers in deck plates. The glass weather stripping was satisfactory. Because of the compressibility of the

insulation, the nuts holding the defroster heater broke or worked loose. The heater often came loose and fell, breaking the gas and electrical lines, which caused several fires.

The location of the defroster was unsatisfactory and caused window breakage from excessive heat on the windshield. It should be mounted on the side or the bottom of the windshield, with circulation fans mounted in the cab to blow across the windshields. The heater should be relocated under the auxiliary seat or in a suitable location in the lower portion of the cab.

Cab Structure

The cab was manufactured by Crenlo Inc., Rochester, Minnesota. Visibility was good from the cab. Some trouble was experienced with screws falling out of overhead, allowing the overhead insulation to sag. The escape hatch could be redesigned to permit easier and faster release. The escape hatch should have a more positive locking device to prevent its being blown away during high winds. The gasket around the hatch cover could not be kept in place. The spring was adequate. Door seals should be improved, as they stuck and pulled loose and snow blew into the cab even when the doors were tightly shut. Latches were all right.

Considerable glass breakage occurred in the cab. It is believed that heat concentration in the top of the cab was the cause of glass starting to crack at the top. It was found during Deep Freeze II and III that excessive breakage of cab glass occurred due to vibration, contortion and temperature. The rear glass on the driver's side should be hinged for easy opening. "Cat walks should be installed on both sides of the cab."[14]

Clutch, Transmission and Chassis

This unit was equipped with an oil-type master clutch which required only routine maintenance. Frequent clutch adjustments, however, were made at the beginning of the operation on some units due to the variety of operators. Subzero oil was used in this clutch.

Transmissions were satisfactory, though it is believed that fifth gear is too fast on tractors equipped with low-ground-pressure tracks, as it causes considerable vibration. Five forward speeds are desirable, but with a top speed of 3.5 mph. Gear Oil Special was used in the transmission and bevel gear compartments with satisfactory results.

Steering clutches were satisfactory. However, GOS passed through the seals during a tractor-train trip to and from Marie Byrd Land, causing brake and clutch slippage. This was rectified by frequent flushing until the oil was removed. Two brake anchor plate failures occurred on

one unit when faulty welds gave way. They were rewelded to the steering brake compartment housing. At McMurdo dust and ash penetrated bellows seals. Final drives were satisfactory, except at McMurdo where volcanic material penetrated to the inside casing. Snow sprockets were satisfactory; however, some sprocket wear was experienced and one sprocket rotation was performed. The chassis was satisfactory.

During Deep Freeze II the clutch shaft seals caused some trouble and were "blowing" after 3500 hours operation. The only transmission trouble encountered was with the forward-reverse selector. After 3200 hours operation the selector lever would jump out of reverse under a heavy load. After two years and 4000 hours operation the snow sprockets were beginning to show excessive wear.

Fuel System

The fuel systems were satisfactory. However, considerable water was found at times in the fuel, which caused some pump failures. Repeated fuel filter changes were necessary because of water. Also, ice crystals formed and clogged fuel tank lines. Alcohol was added to no avail. Tanks were completely drained and the ice melted out, but the condition reoccurred.

A standpipe of approximately three inches in length was installed with very satisfactory results in that practically all fuel pressure failures were eliminated. Tractors have operated in temperatures of -70 F since the standpipe was installed.

Electric System

The battery-charging circuit was very unsatisfactory for Deep Freeze I and II. Several failures were caused by sticking contacts and by voltage regulator filterettes and resistors burning out. The voltage regulator trouble was attributed to vibration. Also, generators did not have sufficient capacity. The generator drive gears and the armature shaft wore out, including the keyway. Idler gear wear was believed to be the cause of generator gear failures; the wear was believed to be caused by lack of lubrication during starts at extremely cold temperatures. The 24-volt, 18-amp system was converted to 24-volt, 40-amp systems with the same results.

The batteries were located outside and in front of the cab. They were cased in a special insulated and heated box; the heat transferred from the engine coolant was pumped through the coils by a recirculating pump. The battery box temperature was controlled by a low and a high thermostat. The thermostats often shorted, running down the batteries. Trouble was experienced with coil ruptures caused by vibration. Coils should be better supported and the battery weight should be removed from

the coils. Battery leads with quick disconnects were unsatisfactory in that vibration caused them to work off and to arc, which resulted in explosions. Battery leads entering the box chafed, causing short circuits. This was rectified by placing conduit clamps on the boxes.

Several windshield wiper motors burned out. Deep Freeze I thought wipers freezing to the glass was the cause; Deep Freeze II thought it was due to congealed lubricant - probably a lube of too heavy a consistency.

Horns and top cab lights had to be removed to get equipment into the garage. The head lights on the radiator gave enough illumination for the driver to operate.

Hydraulic System

Dozer blade hydraulic systems were satisfactory. Hydraulic oil MIL-O-5606 was used in systems with good results. One high-pressure leak found in one of the pump controls was due to a faulty pipe weld.

Drawbar, Winch and Booms

Some trouble was experienced with side frame breakage on drawbars due to the use of an additional tractor as a pusher to help move heavy loaded sleds. The drawbar was hydraulically controlled for positioning. Little America considered it very satisfactory for drawbar shifting in towing sleds and for hitching to sleds; at McMurdo it was considered to be of little use as it would not stay centered. Bar stock was welded on both sides of the drawbar to eliminate the trouble. Hydraulic oil MIL-O-5606 was used in the No. 41 hydraulic control. The Deep Freeze I tractors had no locking device on the control lever to hold the piston in the float position. One was fabricated and installed on each tractor. This was necessary in order to lessen side frame breakage which is caused when towing a heavy load with the piston locked.

The winches during Deep Freeze I and II were useful for hitching to sleds and for other towing purposes. Two hundred feet of 1-1/8-inch wire was sufficient. One of the winches had repeated bearing failures in the PTO shaft. It is believed that this shaft bearing housing was machined untrue, as a new shaft and bearing were installed with the same failure. Gear Oil Special was used in all winch cases. Of the four winches equipped to receive booms only three were utilized.

During Deep Freeze II and III the boom attachment was used extensively on two tractors and was satisfactory with the following exceptions: Hoist shaft nuts on the winch kept working loose, thus constant surveillance was necessary. Side frame breakage was extensive. This was remedied by fish-plating the outside of the frame. The boom-elevating winch

should be mounted more securely. Considerable boom breakage occurred during Deep Freeze I and II on the opposite side and approximately 2 feet above the point where the boom stops contact. Vibration of the tractor, when the boom is raised to above a 45 degree angle, caused the boom to bounce against its stops and then rebound with a snap, which contributed to boom breakage. Another possible cause for breakage was swinging the boom when loaded by moving the tractor. The booms were welded, but breakage reoccurred; they were then fish-plated with fair success. The tractors equipped with booms were used extensively in tank erection and for handling fuel drums and heavy boxed cargo. A swinging boom should be furnished for future operations.

Tracks and Track Carriers

Only routine maintenance was experienced on tracks. Under conditions at McMurdo the track pins were too hard; thev became brittle and broke. These were replaced with soft pins of reinforcing steel which were welded in place. This was bad, since replacing the pins required replacing the links, as they were welded together. Even welded, the pins wouldn't stay in. Caterpillar master pins were replaced with 1-1/4-inch bolts, which partially solved the problem.

Considerable trouble with track carriers breaking at frame anchor plates was encountered. This was the result of metal fatigue caused by constant vibration while underway. Track frame breakage occurred on several units during Deep Freeze I. The break occurred on the inside of the frame about midpoint, near the trunnion. A stronger carrier and some means of reducing snow and ice build-up on carriers would help eliminate the difficulty. This was corrected during Deep Freeze II by welding a diagonal steel brace at each support and extending the upper outside end of the brace to the roller frame.

Only normal wear on front idlers was encountered at Little America. On three occasions the front idler collar broke, causing the idler itself to float. In all cases this occurred on tractors with the greatest number of hours and was caused by metal fatigue. McMurdo reported that front idler collar assemblies failed and in turn bent the rod assembly. The front idler took more abuse in snow and ice because the tractor was always in a climb. The track, where the track roller carries the weight of the tractor, sank in the snow, causing additional weight on the front idler.

Two double-flanged track rollers failed due to ruptured grease seals, but this was considered a routine matter and not due to rigorous weather or use. One double-flanged roller failure was experienced due to metal fatigue.

One chronic trouble at McMurdo was the use of stationary wooden track-carrier blocks rather than the conventional rollers. The dirt and rock of McMurdo Sound created friction which wore them out at about one per day. Attempts were made to cover the boards with meridian steel, with no greater success. At Little America it was found that reversing the blocks doubled their life. The bolt that holds the blocks was located where the track links ride on the blocks. This resulted in uneven wear of the block. The bolt holes were relocated allowing the track link bushing to ride on the carrier, giving longer life to the wooden blocks.

Unsatisfactory results were experienced during Deep Freeze I and II with hydraulic track adjusters, although heat was applied to the adjusters while attempting to adjust the tracks. The seals on the track adjustment were a constant source of trouble. They should be changed to a more cold-resistant material. Although routine maintenance was observed with tracks, the tracks had a tendency to wander against the frame; pipes holding the oak runners broke at welds between pipe and frame.

Ignition Systems

The ignition system on the starting engine was very satisfactory during Deep Freeze I, with only routine maintenance required. During Deep Freeze II, starting engine magnetos gave some trouble due to snow blowing into shielded wiring then melting and running down into the magneto. In such cases, heat alone was not enough, and the magnetos were dismounted and cleaned in order to make them operative. Excessive fouling of spark plugs occurred during both Deep Freeze I and II due probably to the grade of gasoline, though no definite cause was discovered. Radio interference suppression units were incorporated in the Deep Freeze I system. No trouble was encountered at Little America; however, at McMurdo the filters developed internal shorts.

D8 WITH TORQUE CONVERTER

One D8 tractor with a D337 engine and torque converter was delivered to McMurdo. This machine was never given an adequate trial. The engine failed when it threw a rod after a few hours of operation. The failure, however, was due to an improperly installed rod bearing which had been replaced during overhaul in Davisville. The tractor was inoperative until spring, when a replacement engine was delivered. This engine was not designed to fit the chassis of the tractor, as it was some two inches too narrow and five inches too short. Extensive field modifications were necessary to effect installation.

The machine operated satisfactorily for 153 hours, at which time the new engine failed. The bolts securing the flywheel to the crankshaft sheared. Inspection revealed that the bolts (factory set) had not been

either properly tightened or hardened, as the bolt holes in both the flywheel and the crankshaft were worn into pronounced eliptical shapes. The long diameter of these holes was about half again the short diameter. The engine was overhauled and reinstalled. However, the machine was not operated again prior to Detachment One's departure as the torque converter unit needed to be modified.

It was felt that not enough experience had been gained during Deep Freeze I to thoroughly evaluate this piece of equipment. It is believed that this machine will be highly satisfactory if the "bugs" are finally eliminated.

Section XII

CONSTRUCTION EQUIPMENT

ROLLERS

The snow rollers were designed and fabricated by the U. S. Naval Civil Engineering Laboratory, Port Hueneme, California. Each roller weighed 5 tons dry.

At McMurdo, three rollers were used during compaction tests and for compacting skiways. The rollers quickly filled with drifting snow. The towing bars and framework broke in extreme cold when the rollers were pulled in tandem.

Three rollers were used at Little America. They were hitched triangularly and towed by an LGP D8 tractor. These were first used on the road from the ship off-loading area to the camp site. This operation was of little or no value because of the continuous travel over the road by heavy equipment and heavily loaded sleds. The consistency of the snow and the amount of time between loads would not allow the snow to harden. Compaction under these conditions was impossible.

The rollers were later used in the construction of the airstrip and aircraft parking area. After the runway was bulldozed, one-half of the strip was rolled to provide a smooth surface for aircraft take-off. The scrapers, which were mounted on the rollers to prevent accumulation of snow, were not sturdy enough. Snow built up on the roller and dug holes in the surface of the runway. Trouble was also experienced with the roller frames. The front section, where the tow bar was attached, would twist and break at the corners where they were bolted together. To remedy the shearing of the bolts, these corners were reinforced with steel plates welded to each of the corners.

SNOW MIXERS

One snow mixer was used for compaction tests at McMurdo during Deep Freeze I. Two tires blew out in the extreme cold. Skis were fabricated to replace the tires, as no spares were available. The skis were not successful, as they created excessive drag.

The hydraulic pump failed. The hydraulic cylinder used to raise and lower the rotor was replaced with a large screw jack, as no spare pump was available. Failure of the pump prevented raising of the rotor and resulted in the tongue being torn off. All rubber fuel hoses on the engine were replaced with copper. Electrical trouble occurred in the same manner as with the D8. A short developed between the ammeter and the battery. The winterization and battery box were satisfactory. It is recommended that a larger fuel tank be provided for the snow mixer to allow longer usage without refueling.

During Deep Freeze II a snow mixer was used extensively in surfacing the ice runway. The ice chips from the mixer were bladed off with the snow planes to low areas close to the location where the mixer had worked. It was found that it was best to operate the snow mixer in second gear with the tractor pulling in low gear.

One snow mixer was shipped to Little America V. It was manufactured by the Seaman Motor Company, Milwaukee, Wisconsin, and had a Caterpillar Model D315 engine for a prime mover. The snow mixer was used a total of 29 hours on Operation Deep Freeze I.

DRAGS

Snow drags were used through the year at McMurdo to level the skiway in compaction tests, and to distribute snow on the ice runway. The towing chain and the pad eyes tore off and were replaced with cable strap.

Two prefabricated drags with 6-inch by 8-inch by 10-foot runners and Marston matting decks were made up at McMurdo and delivered to the South Pole. They were handy to use as they were only 8 inches high. The drags were also good for hauling drums as they could be unloaded and loaded easily.

SNOW PLANES

One snow plane was used at McMurdo. A simple planer would have been better for this type of operation. The hydraulic system was of insufficient capacity to raise and lower the blade at a satisfactory rate. The framework was underdesigned and broke repeatedly when used to level the unprocessed sastrugi. Many man-hours were spent in welding and repairing metal failures which occurred in the extreme cold.

The snow plane was modified for use as a planer by bolting the two side cutter plates to the blade. This eliminated all the horizontal controls, as the blade was always perpendicular to the direction of travel. Several problems resulted. The blade side plates bent in when

turns were made. The pin tying the planer turntable to the frame broke in three places. In replacing the pin, the entire support broke off. The pin and support were replaced. The turntable pin bent, so that the turntable froze and the hydraulic cylinder which rotates the turntable bent a shaft. The vertical cylinder mounts on the blade tore off repeatedly. The cylinder side pins were too short which allowed the cylinder mount to spread and release the pins and the cylinder.

The tow bar broke when a sharp turn was made, as the joint of the bar was designed for vertical movement only. A modified tow bar was made to allow lateral movement. The steering mechanism on the rear end broke and had to be remodeled.

The snow planer at Little America was used primarily to level and maintain Kiel Field skiway. This was accomplished satisfactorily. Since the use of the power system for controlling the blade required the use of a man to operate the controls, the manual system was employed. By presetting the height of the blade, one operator driving the prime mover (D2 or D4) can effectively maintain an amazingly smooth surface.

ICE AUGERS

The hydraulically operated ice auger attachment for the D2 tractor broke down many times during runway flooding operations at McMurdo. The hydraulic motor failed with a split casing on three occasions, although it had been welded and reinforced. A replacement for this unit was ordered. The downhaul and retract cable failed frequently. The controls were not sensitive enough to allow gradual drilling without lifting a major portion of the weight of the tractor.

To drill through the 12 to 15 feet of ice found in McMurdo Sound, extensions had to be put on the slide and jack shaft. This made the unit top-heavy and caused the connections to the tractor to shear off frequently. The entire mounting arrangement had to be modified to strengthen it and to provide accessibility for adjustment. Hydraulic arrangements of any sort do not seem to work too well at extremely cold temperatures. A simple mechanical take-off as developed for posthole diggers would appear to be a solution to this problem.

During movement of the D2 with auger, the bolts holding the auger sheared off. The auger extension as designed, although strengthened with bars welded along the inside, was very flimsy. It vibrated considerably with the movement of the tractor. The hydraulic motor casing broke the first time after only 6 feet of drilling. Also the downhaul cable stretched and broke. This cable bears the weight of the entire rear end of the tractor when downhauling the auger. A method of tightening the downhaul cable with a tug-along was used so that the operator did not

have to watch the winch continually to prevent the loosened cable from crossing and tearing. A smoother control mechanism is required to allow finer adjustment of pressure on the auger to prevent cables from parting. Perhaps some sort of a spring-loaded winch could be devised.

PUMP WANIGANS

The two pumping wanigans for McMurdo were constructed as lightly as possible for reasons of transport. They had to be straightened in the field for operations. A heavier electrical generator, preferably diesel, would provide reliable electrical power over a longer period of time. The light units furnished did not last more than 500 or 600 hours at the most, and were required for continuous operations during the winter night when flood lighting was required.

The Hercules pump had to be repacked to allow priming by the vacuum primer. The pump was operated at 60 psi. At that pressure the output through 300 feet of 2-1/2-inch hose was calculated to be approximately 1.6 $feet^3$ per second. The exhaust flange on the pump cracked and required welding. Some operating difficulties were experienced due to icing.

"The units of the prefabs were too big. One wall was 20 feet long 8 feet high and only a few inches thick. It must be remembered that a 45-mph wind at McMurdo is not uncommon. It took several pieces of equipment and several crews of men to assemble one unit, and even at that it was quite a job."[7]

TRAXCAVATORS

Caterpillar Model 955 (LGP)

McMurdo

Four Model 955 Traxcavators were delivered to McMurdo in December 1956. The first one was flown in early in the month to assist loading aircraft for polar flights. Following one day of operation, the bolts which secured the final-drive extension to the final-drive housing failed. The bottom bolts on both sides of the machine failed following noticeable elongation. It was deduced that the bolts failed in tension as a result of insufficient rigidity in the final-drive extension. This was borne out by subsequent failures. Every machine, without exception, failed in a similar manner.

The first attempt at modification was to increase the number of bolts from six to twelve. This was unsuccessful, as failure reoccurred after two days of operation. The next modification was in accordance with

BUDOCKS' recommendation. A rigid brace was placed between the transmission housing and the final-drive extension housing. No further bolt failures were experienced. However, the undue stress was transferred by the brace from the connection to the sprocket and to the bearing at the outer end of the final-drive housing extension. Severe wear on the sprocket was quickly evident, and replacement was necessary after about 400 hours. One bearing failure had occurred by the time Detachment One departed. Sprockets continued to have excess wear during Deep Freeze II.

During Deep Freeze II several final-drive hub assemblies broke. It appeared that the hub was not heated deep enough to take a good weld. It also could have been caused by the excess weight on sprockets. This undue stress on the sprocket was also transferred to the track rollers, resulting in numerous failures. A further modification was recommended by BUDOCKS. This consisted of removing the excess weight from the final-drive extension by placing a rigid brace between the tractor chassis and the track frame.

During Deep Freeze II it was found that engine support cross members were not heavy enough to take care of the added width of the tractor. Bending of the track roller frames caused the front idlers to toe in at the bottom.

The tractors are back-heavy, putting excess weight on the rear track rollers and causing roller shafts and rollers to fail. By placing the forks on the front of the tractor and carrying a pallet with three or four barrels of diesel, both the front and rear axles appeared to be balanced and failures were eliminated. They traveled well in reverse, consequently it is believed that the unbalanced condition can be alleviated by moving the center of gravity forward.

During Deep Freeze I and II much trouble was experienced with both losing and shearing bolts which secured track shoes. In the first instance, the bolts were too short to permit inclusion of lock washers, as full threaded nuts were impossible. To eliminate bolts falling out of tracks, the nuts had to be welded to the bolts; but then the bolts sheared. It is presumed that the bolts simply were not large enough for the stress involved.

It was found during Deep Freeze II that the rear vision is very poor, which makes it difficult for drivers to winch or back up the tractor to hook onto sleds. Aside from these constant and chronic faults the Traxcavator 955 was a fine machine. It did a fine job during Deep Freeze I moving cargo over extremely difficult trail conditions.

Deep Freeze II felt that the LGP 955 Traxcavator was not suitable for bases located on ground, although the many deficiencies in design could be corrected by strengthening the overall suspension system to eliminate

failures caused by the added width of the tractor. Any additional tractors procured for McMurdo should be standard rather than LGP design, as wide tracks are not suitable.

Little America

Three LGP and one standard 955 Traxcavator were taken to Little America during Deep Freeze II. Attachments included snow blades, forks, buckets, and booms.

Engine. The engines operated satisfactorily throughout the operation, with normal breakdowns. An access should be provided to accommodate the duct of a Herman Nelson heater so that the engine may be preheated more efficiently.

Starting Engine. The starting engines operated satisfactorily, but engine controls are inaccessible.

Cab Winterization. The 1030C South Wind heater was used and was satisfactory. The windshield defrosting tubes should be rerouted. In their present location by the door, personnel getting into the cab use the defroster duct for a handhold. A defroster should be installed on the rear window on the driver's side for improved visibility.

Cab Structure. The escape hatch should have a locking device which will hold during extreme winds. Visibility to the rear is very poor and hampers operations when towing sleds. Provisions should be made to increase the field of vision so that towed equipment may be viewed without having to half stand, half sit. Cab glass breakage was quite extensive due to vibrations and contortions of the structure. The cab is much larger and heavier than is necessary.

Clutch, Transmission and Chassis. All were satisfactory, except that the master clutch was inaccessible for adjustments.

Fuel System. Trouble occurred with gasoline freezing in the line from the tank to the carburetor. A new line was installed without the many turns and dips of the original installation, and this difficulty was eliminated. There was a little trouble due to ice forming in the lines from water or snow in the fuel, though this never became a major problem.

Electric System. The generating system was not satisfactory. Many failures were experienced, probably due to vibrations affecting the voltage regulator. The regulators were shock-mounted, but the mounts did not hold up under the extreme pounding. The lights should be remounted to give more light forward and to the sides.

Hydraulic System. Very satisfactory.

Winch. The winch was seldom used, so a complete evaluation cannot be given.

Tracks and Track Carriers. Extensive track breakage occurred at or below -40 F. Operation of 955's at such temperatures was kept to a minimum. More sturdy drive-chain links are needed to compensate for the wide grouser pads. The final-drive filler hole should be situated so that lube oil can be pcured in easily. The present filler hole necessitates standing the machine on its nose for proper filling. New filler holes were drilled on equipment available at Little America and proved successful.

The final-drive extensions were a source of trouble, as the belts connecting them to the final-drive housing sheared off. The modification recommended by Caterpillar was not satisfactory. Finally, a bead was welded around the flange of the extension. This, with a redesigned brace, eliminated further trouble.

Hallett

Two Traxcavators with attachments were supplied. Most of the problems encountered on this type of equipment were of a standard nature and not attributed specifically to antarctic operations. Engine and gear lube was used during the sub-zero winter and standard lube 9170 was used during the warmer months. These vehicles were operated on standard tracks at all times.

The master switch, choke, throttle, and starting engine gas line and petcock should be relocated if possible to provide easier accessibility to an operator wearing heavy winter clothing. Defroster hoses should be relocated away from door frames if possible or replaced by flexible metal hose, as the operator tends to use the door frame as a handhold when entering or leaving the vehicle.

Wilkes

The Caterpillar Model 955 LGP Traxcavator was the only type of heavy equipment used and it proved highly unsatisfactory in service. Every part of the suspension system failed at some time during the year. Heavy welded steel bracing was fabricated and installed on the final-drive housing in an attempt to prevent further failures of the studs attaching the final-drive housing to the tractor frame. This reduced the number of failures but did not eliminate them.

Third and fourth gear ranges were blocked off early in the year and used after that only for icecap trips. For fear of further damage, the tractors were not abused and were not used for several jobs where they would have been useful. The tractor appears grossly underdesigned.

The current and voltage regulator on the electrical system did not function properly and as a result several generators were damaged. In one case the generator locked, with the result that the housing around the generator drive gear was damaged.

The escape hatch of one tractor was damaged by the wind and the device for locking the cab doors open was ineffective.

The armored cable on the starting engine seemed to cause short circuits and was removed, with the result that no more shorts occurred. The starting engine and the master clutch were so located as to be very difficult to work on.

The track pads (grousers) had a tendency to work loose, especially on the wide tracks. This had to be constantly checked and tightened. At Wilkes Station a low-ground-pressure track is rarely required and a standard model tractor would have been effective.

Ellsworth

Eight 955 LGP Caterpillar Traxcavators were furnished. The number of attachments furnished (two booms, two buckets, four forks, and four snow blades) was ample for construction requirements. No change of this number is recommended.

On the way to Antarctica, braces were installed on the final-drive extensions of two 955's and prefabricated for the rest of the tractors. After fabrication of these, a BUDOCKS message prescribed an additional brace to be installed on the track roller frame to remove some of the load off of the final-drive extension. Materials for this modification were not available at that time. After the first five days of operation until completion of construction, twenty-four of the 1/2-inch studs securing the final-drive extension housing failed. No correlation with specific uses of the various tractors could be made.

The 955's were too heavy on the rear of the tracks for towing. The engine should be moved forward to change the balance for improved overall performance on soft snow such as encountered in the antarctic. A hydraulic drawbar shift should be added. Guides should be installed to prevent the winch cable from riding up over the edge of the winch drum when pulling at an angle.

Caterpillar Model HT-4

One HT-4 was used at Little America V. It was equipped with bucket and fork attachments, a D315 engine, a Model 44 hydraulic control, snow sprockets, and 24-inch grousers. This machine proved very valuable throughout the entire operation. It was used as a fork lift or with the bucket attachment. A larger bucket attachment of lightweight construction would have been more desirable for movement of snow. More machines of the same type would have been very advantageous in off-loading operations. Adequate spare parts were provided.

Engine and Engine Winterization. One oil pump shear pin failure occurred. This failure was a result of the engine being improperly preheated before starting with 9170 engine oil in the crankcase. A failure of this type is time-consuming since the oil pump is hard to reach. After this failure was repaired, the 9170 motor oil was replaced with sub-zero engine oil. Later, a complete gear train failure was experienced, with no apparent reason found for the failure. Considerable trouble was encountered with hour-meter drive gears stripping out with no satisfactory explanation as to the cause.

Winterization on the HT-4 was very satisfactory. This machine had shrouding around the oil pan to utilize the exhaust from the 939A engine coolant heater. By using sub-zero oil in the crankcase, preheating could be accomplished with the heater to -55 F with no winds. However, quick heat was required to preheat the electric starting motor on the starting engine. Quick-disconnects for use with the Vapor Car Heater should be relocated for access when the Traxcavator attachment is in down position. The battery box and the battery box recirculating pump are satisfactory. Ether primers were not required. Kim Hotstarts were tested and found to be inadequate and unnecessary.

Starting Engine. The starting engine was satisfactory. Trouble was experienced with belts on the electric starter. This was caused by a lack of clearance between the engine compartment paneling and the flywheel. Several had to be replaced. Sub-zero oil was used throughout and normal maintenance was required.

Cab Winterization. Insulation of the cab was satisfactory except that the insulation should be removed from over the inspection covers. Considerable trouble was encountered with bracket breakage on the 1030C personnel heater. A more sturdy mounting is required.

A manifold should be installed on the outlet side of the heater to distribute the heat more evenly and the defroster should be relocated to allow the heat to be applied at the bottom of the glass.

Cab Structure. The escape hatch should have an easier and quicker method of releasing, and an exhaust extension should be installed to route engine exhaust gases aft of the cab.

Clutch, Transmission and Chassis. Considerable maintenance was required on the master clutch and the control linkage. Trouble was encountered with binding in the clutch linkage caused by a lack of lubrication. The clutch throw-out collar wore out and required rebuilding and machining. This was also caused by lack of lubrication. Upon reassembly of the collar it was packed with grease. The original means of lubrication for the collar was an oil cup, which was not satisfactory in extreme cold. The transmission was considered satisfactory. Final drives, the bevel gear compartment, the steering clutch compartment, sprockets, track frames and the front idler were all satisfactory.

Fuel System. A standpipe should be installed in the fuel tank.

Electric System. Considerable voltage regulator trouble was experienced. Upon inspection, the following was found: (1) shorted filterettes, (2) stuck contacts, and (3) burned resistors. Two generator failures resulted from dirt in the generator and from a broken spring in the vibration dampener. Battery lead quick-disconnects were not suitable. Standard bolt-type battery clamps should be used. Vibration caused quick-disconnects to work off the terminals, causing shorts and blowing up the batteries.

Hydraulic System. The hydraulic system was satisfactory. Only routine maintenance was required. There was only one hydraulic hose failure.

Drawbar, Tracks and Track Carriers. There was an excessive loss of track master pins. Otherwise the performance of the drawbar, tracks and track carriers was satisfactory.

Maintenance. The machine was hard to work on in extreme cold due to the compactness of the engine, the accessories, and of the Traxcavator unit in general.

POL. Sub-zero and 9170 motor oils and arctic greases, diesel fuel and hydraulic fluids were used. Arctic-grade gasoline was used in the heaters and starting engine. Gear Oil Special was used in the transmission, bevel gear and final drives. Pre-mixed permanent-type antifreeze was used in the cooling system.

Section XIII

MISCELLANEOUS EQUIPMENT

SNOW MELTERS

McMurdo

A snow melter was installed in the power plant at McMurdo in January 1956 and was still operating without breakdown when Deep Freeze I forces departed in January 1957. It was also used during Deep Freeze II and III. Exhaust from the 100-kw D342 Caterpillar diesel generator engine was used to melt snow. This snow melter was built by the U. S. Naval Civil Engineering Laboratory, Port Hueneme, California. It was found during Deep Freeze II that 24 inches is the maximum back pressure that should be on this engine. This is an effective and economical means of melting snow. Drain plugs should be added to the melter to assist in cleaning.

Ellsworth

A bitumen heating kettle was used as a snow melter for the temporary camp, as well as to produce water for freezing in the 132 deadmen placed during the construction. The kettle is ideal as a snow melter.

For water production by snow melting, the circulation pump should be removed and blanked off. The paint should be removed from the fire tubes and some sort of coating applied to prevent scaling, or the tubes should be replaced with a non-scaling material such as monel.

Spark plugs on the engine failed and by chance a similar engine was aboard the cargo ship and could be cannibalized. Spare plugs should be shipped with the kettle.

PORTABLE PUMPS

Three assault fuel pumps, manufactured by Gorman-Rupp Company, Mansfield, Ohio, were shipped to Little America V. These pumps were Model 04A-MVG4D, self-priming, centrifugal, capacity 350 gpm. A four-cylinder Wisconsin gasoline engine Model MVG4D was used as a prime mover. The pump was portable, mounted on rubber-tired wheels.

The pumps were first used to transfer bulk automotive gasoline from ten 800-gallon aluminum tanks mounted on two 20-ton Otaco sleds into ten 10,000-gallon collapsible rubber storage tanks. One pump was later set up to transfer aviation gasoline from the ten 800-gallon aluminum tanks into a 100,000-gallon steel storage tank. One pump was placed in a pumping station to transfer avgas from the 100,000-gallon tank into a refueller.

The pumps were satisfactory in all operations. Only normal maintenance was required. Spare part support was adequate.

WELDING MACHINES

McMurdo

Two 400-amp GE welders were located at McMurdo. These units were used during the construction of the fuel tank farm but did not bear up well under the long hours of welding with heavy rod. The engine on one and the generator on the other burned out. The remaining portions were combined to make one good welder, which was installed in the welding shop. A Caterpillar Twin-Arc 600-amp unit, an excellent machine, was obtained in late 1956.

Little America

Two General Electric 400-amp welders with Chrysler Industrial Engines (Model 6A226) were shipped to Little America. These welders were portable in that special skis were fitted on the bottom of the tires to allow mobility over the snow. The ski design did not prove satisfactory because the rubber in the tires hardened and cracked in the extreme cold. Also, the design of the skis was too heavy for the undercarriage of the welder. When turning the machines, the skis dug into the snow and bent the axle or broke the tow-bar assembly. This was rectified by removing the undercarriage and mounting the welders on an Army one-ton cargo sled.

The engine and generator compartment was not sufficiently enclosed for preheating the engine or for keeping out the snow. The engine was not equipped with the Universal Heating Kit. However, it was possible to use a Vapor Car Heater to heat the cooling system. This was accomplished by using quick-disconnects to connect the portable circulating water heater to the welder's cooling system. This provided sufficient heat for the coolant only. The Herman Nelson BT 400 heater was used for preheating the entire unit.

Use of 9170 motor oil in the crankcase was satisfactory. Except for one engine failure caused by the governor, routine maintenance was observed. The machine was operated at temperatures of -50 F with satisfactory results. Spare part support was inadequate. "The 18-8 Columbian rod was the main and best welding rod used."[29]

Byrd

The Libby arc welder worked well during the summer. The welder was stored outside for the winter and was damaged when it was dug out of the snow.

Hallett

A welder Model 1ND64 Type 226 was received mounted on wheels. The wheels were removed and the welder was mounted on a one-ton sled. No mechanical difficulties were encountered in the operation of this equipment.

Ellsworth

The arc welder furnished was used only on two days. No trouble occurred.

AIR COMPRESSORS

McMurdo

One gasoline-powered and two diesel-powered air compressors were located at McMurdo. The Davey 315-cfm compressors powered by a Hercules diesel engine did not work well at first because of starting problems. As they did not have pony engines, the starting motors were quickly burned out by overzealous welders using welding machines to start the compressors. An external coolant heater was not available to start the diesels until one Vapor Car heater was repaired. The gasoline compressor served well. Due to condensation problems, compressors are difficult to use in cold weather but during the summer months are perfectly satisfactory for McMurdo.

During Deep Freeze II, a 210-cfm LeRoi compressor with a UD14 International diesel engine started with no heater and without the aid of ether. In temperatures of -20 F it started much better than the Caterpillar engines that used hotstarts.

Little America

One Davey air compressor Model 315 WDS-TS with 315-cfm capacity was shipped to Little America. The prime mover for this machine was a Hercules Diesel engine, Model DRXC. The air compressor was portable in that skis were fitted on the bottom of the wheels to allow mobility over the snow. This design did not prove satisfactory because the skis dug into the snow when being turned, causing excessive strain and breakage of the tow bar. It is recommended that the unit be placed on a sled similar to the Army one-ton cargo sled.

The engine and compressor compartments were not sufficiently enclosed either for proper preheating or for keeping out the blowing snow. It is suggested that the bottom be enclosed to aid in keeping out snow and preheating the entire unit. The engine was not equipped with a Universal Heating Kit. Quick-disconnects for the cooling system were installed to accommodate the use of a circulating coolant heater. This provided heat for the coolant only. The Herman Nelson BT 400 heater was used to heat the entire unit.

This unit was used with satisfactory results in the fabrication of a 100,000-gallon steel aviation gasoline storage tank and to take ice soundings with a pneumatic soft-coal auger. Only routine maintenance was required on this machine for 115 hours of operation. Spare parts support was not adequate.

Wilkes

The LeRoi air compressor, the Cleveland wagon drill and the Joy jack-hammer all operated well. The wagon drill, however, would not drill in a mixture of ice and rock.

Ellsworth

The 210-cfm LeRoi air compressor furnished was not used.

WATER CARRIER (MARK II)

McMurdo

This unit proved too fragile for hauling water over the terrain at McMurdo. It was built in as a permanent snow melter at the galley and was operated with a Vapor Car Heater. No trouble was experienced with the unit when used in this manner. (The Hallett diesel that was installed to melt snow with its exhaust had a cracked block upon arrival.)

"The Mark II is a fine piece of equipment. It can be used as a snow melter or to draw water from a lake. It can be stored and carried in an insulated tank or drawn to a fire. The main trouble was with its operation. There were three sets of coils for heating. The bottom set, assembled out of pipe and fittings, carried Prestone from the Vapor Car Heater. When the carrier was towed over rough ice the pipes developed leaks which contaminated the water. To tighten these leaks the bottom coil had to be disassembled piece by piece. A welded coil should be used. The brackets holding the coils had to be removed by a cutting torch in order to remove the coils. This was because the coils were assembled inside the tank and not installed as a unit. The one-cylinder Hallett engine never ran for any length of time. The Vapor Car Heater was the main

source of heat. One-cylinder engines will not work in the antarctic. Several types were used and all quit after 10 to 15 hours of operation. (Most operation was at temperatures of +10 to -5 F.)"7

Little America

One 1000-gallon water carrier was shipped to Little America V but was not required for Deep Freeze I. This unit was fabricated by the U. S. Naval Civil Engineering Laboratory, Port Hueneme, California.

VAPOR CAR HEATERS

At McMurdo this unit proved to be a satisfactory external coolant preheating unit. One electrically driven unit melted water for the galley. A gasoline-driven unit used in the garage was not repaired until mid-winter due to the lack of spare parts. It then served to preheat equipment. Fuel consumption averaged approximately 2.0 gallons per hour.

The portable circulating water heater, manufactured by Vapor Heating Corp., Chicago, Illinois, consisted of a heating unit mounted on a sled. It is designed to circulate heated water to other equipment through its supply and return hoses. A gasoline engine and/or an electric motor drives the combustion air blower, fuel pump, circulating pump, and magneto. The rated output is 150,000 Btu's per hour.

The gasoline engine, a Power Products Model AH36-FST1039SP, was used for the propulsion of the Vapor Car Heater. It was difficult to start at temperatures of -40 F and below, even when using ether starting aids. Low-temperature grease was used in the bearings of the electric motor. At -50 F the motor starting load would trip the circuit breaker.

Although the Vapor Car Heater performed according to specifications, this unit was not satisfactory for preheating equipment in extremely cold temperatures. The heater would heat the coolant to proper prestarting temperatures but the transfer of the heat from the coolant to the lubricating oil was negligible. In many cases the Herman Nelson BT 400 series heater had to melt the snow out of the engine compartment of a piece of equipment before the engine could be turned over. Thus, the Herman Nelson heater was better suited for engine preheating than the Vapor Car Heater. Spare part support for this machine was adequate.

A unit delivered to the Pole was never used during the construction period as the temperatures were warm and equipment starting was easy.

HERMAN-NELSON HEATERS

McMurdo

The Herman-Nelson heater proved to be the simplest and most flexible unit for preheating a cold engine.

Little America

On Operation Deep Freeze I, twenty-three portable gasoline-burning Herman-Nelson heaters (Model BT400 series) were used. Output was variable up to 400,000 Btu's per hour. These heaters were used for quick heating of equipment, for emergency heating of temporary housing, for heating equipment under repair, and for the comfort of personnel performing this work. This type of heater was very beneficial in that it could be easily moved from one location to another, and because it generated nontoxic, fume-free heat.

The maintenance required was routine. The oil was changed every 8 hours and the fuel filter was inspected for icing. In temperatures below -50 F when winds were encountered, trouble was experienced with fuel filters icing in spite of the fact that all gasoline was filtered through a chamois skin at the time of refueling and alcohol was added periodically. Carburetors on the gasoline-driven units had a tendency to freeze.

Fuel control assemblies became inoperative at extremely low temperatures (-60 to -78 F) due to ice crystals unless heat was directed upon them at about 15-minute intervals. The check valve from the fuel atomizing nozzle, in which a neoprene seal was located, had a tendency to ride out of position thereby resulting in fuel pressure drop. This would also let gasoline leak from the control unit into the combustion chamber, causing after-burning when securing the heater.

Only three major engine failures were experienced. These occurred during the summer season and with very low engine hours (7, 14, and 24 hours). On all three units the crankshafts broke at the rear main bearing. The exact cause was not determined but it was believed it was due to faulty material.

Two sizes of ducts were used with these heaters. The 12-inch duct was readily connected, while an adapter was required with the 6-inch ducts. The ducts were a plastic which was very flexible when warm and brittle when cold. They proved to be satisfactory if they were warmed before being compressed for storage and expanded for use.

This heater was highly advantageous to the operation and maintenance of equipment. Its quick heat was readily available to supplement the winterization kits incorporated on the equipment, to supply heat for the removal of accumulated snow in engine compartments, and to supply heat for tractor repairs outdoors.

Byrd

Herman-Nelson preheaters were used to preheat vehicles, aircraft and the inflation shelter. They performed very well, but two weak points were noted. Large amounts of carbon formed in the engine and heater combustion chambers. The starter cables should be lengthened.

South Pole

Two Herman-Nelson preheaters were used at the South Pole. Both performed satisfactorily. One was an old 300,000 Btu per hour model and the other was a new model BT400. The gasoline engine for the model BT400 was kept inside and warm when not in use to eliminate the crankshaft failures experienced at McMurdo. The units proved invaluable in assisting equipment starting, in melting iced-up containers, and in assisting aircraft maintenance and starting.

A Herman-Nelson heater, or one similar, should be provided for the use of mechanics and others in the initial stages of construction before permanent facilities are erected.

FLOODLIGHT TRAILERS

The trailer unit was not used as such at Little America. However, the generator units and floodlights were used to good advantage during the winter night. One unit was installed in the garage, and the floodlights were mounted on the roof to light the equipment area. Another was mounted in the rear of a weasel and the floodlights were attached to the roof. This so-called "Roving Aurora" was extremely useful for operations requiring light away from the equipment area. The fact that the generator was situated in the heated weasel cab solved the preheating problem. This unit also acted as a beacon for aircraft during winter night operations.

Section XIV

MAINTENANCE AND REPAIR OF EQUIPMENT

GENERAL SITUATION

McMurdo

Insufficiencies

The history of equipment and equipment maintenance at McMurdo is not a pleasant one. It was a constant struggle by too few men in meager facilities to keep equipment operational under the most adverse circumstances. From the 20th of December 1955 until 13 February 1956, all work on equipment was done outside with the assistance, after 13 January 1956, of the Polar Field Kit. On 13 February 1956 the garage shell was completed. At this time the work could be brought inside.

On 9 March, the day the last ships left McMurdo Sound, the equipment situation was absurd. Only three weasels were operative. All four Carylifts were down, and every tractor was down except one. All equipment had been run at "General Quarters" precedence since its arrival and now the lack of repair facilities was showing drastically. Therefore, as soon as possible, simultaneously with other construction, the pieces were overhauled.

By the beginning of May, the overhaul had progressed to a point where garage personnel could start to finish off the interior of the garage. Benches were built, parts boxes opened, parts sorted and stored where easily accessible and accountable. Parts were inventoried and a system for recording was established. A monorail was installed overhead in the garage. By the middle of May, the garage was ready to start work on snow and ice runway equipment. It is estimated that four to five hours was spent on equipment repair, modifications and servicing for one hour of actual work at the construction site. The effect on equipment, as predicted by those concerned, was disastrous. By the time Deep Freeze II forces arrived in the antarctic in October 1956, the equipment was worn out. By bringing in additional equipment the mission was completed, but only by the untiring efforts of the men involved.

Some of the factors that are considered of primary importance which led to this unpleasant situation include: shortage of manpower; deficiencies of equipment, including non-standard pieces; insufficiency of repair facilities; lack of proper parts data to enable mechanics to rapidly dig out parts (no cross reference for parts numbers was available); and the short construction period.

Shortage of Manpower

The manpower situation was a realistic problem. When the wintering party was selected, it was realized that as many mechanics and drivers as possible had to be retained consistent with the demands of other divisions of the facility. Accordingly, five mechanics and four drivers were retained. In addition, one aviation electrician was retained per his request to double up as an extra garage hand. One machinist mate and one machinery repairman helped to fill out the garage staff. In peak periods, a cook put in time in the garage, assisting in overhaul work. Since the steelworkers were so closely allied to the equipment repair, the three steelworkers were placed under the garage organization. A chief boatswains mate also assisted greatly. The four drivers were assigned to maintain their own equipment insofar as possible, and were utilized in runway construction. Since work was continued on a 24-hour basis most of the time, the above personnel were spread very thin.

Because of so few drivers, weasels were operated by every person in camp, which resulted in more rapid deterioration. Gradually most of the personnel in camp became proficient drivers of tractors as well as weasels, but having many operators is always hard on equipment.

Insufficiency of Equipment

The equipment would have been ample if the D2 tractors had held up under the working conditions encountered. The D8, the D4's and all other equipment held their own in good form. The D2's were just too light for the job. Consequently the two D4's bore the brunt of all work in camp and the D8 did 90% of the work on runway construction. The D2's fell to pieces during off-loading. Afterwards they were suitable for light work around camp and at the runway. If the standard D4's had been obtained by Deep Freeze II forces as requested by McMurdo the problem of transportation would have been much simpler after 15 October 1956. The weasels proved to be the only dependable personnel carrier for this area where the vehicle must survive every condition imaginable—dirt, rocks, ice and snow. No other vehicle could have done this job.

It is extremely doubtful if more could have been done to conserve the equipment under the conditions that existed. The men at the garage have been commended more than once for their untiring efforts. With additional repair facilities, the picture would have changed considerably;

with more mechanics, repairs could have been made more easily and quickly. With D4's instead of D2's, the picture should have been different; at best it is hoped that the situation will not repeat itself. It is hoped that training might improve so that care and maintenance of the vehicles might improve. But in spite of the multitude of troubles experienced, the mechanics and drivers were able to keep ahead through untiring efforts. This was evidenced by the fact that although servicing was done by the drivers when it could be done, not one valve or ring job was required in any diesel engine. There was only one track roller failure throughout the 13 odd months spent at McMurdo. This is true in spite of the fact that every piece of equipment had more hours of operation on it than would be expected under ideal conditions in the States where good maintenance facilities are available.

Recommendation

It is heartily recommended that additional repair facilities and men be assigned future operations of this nature and that mechanics relieving wintering crews be transported early so that they might more readily learn the peculiarities of the jobs in this region.

Little America

Maintenance at Little America was routine as to lubrication problems. However, work that PM's usually involved was always in the open or under temporary shelter in not too favorable working conditions.

The garage is a 20-foot by 56-foot panel-constructed building with a hardwood deck. The doors are hinged from the top and open inward. This arrangement was not satisfactory from a safety standpoint and required too much garage space.

Located within the garage were the steelworkers' shop, the machine shop, and the toolroom. There were two small test shops within the garage. One was used as a battery shop, and the other was used as an office and storage space for the portable Herman Nelson heater. The garage was not lighted satisfactorily, and additional lights were required. Fluorescent fixtures are recommended. The building was heated by forced air from the generator (power plant) building. This heat was supplemented with a 55,000 Btu space heater. Occasionally, additional heat was required from the Herman Nelson heater.

The garage was not large enough to accommodate the Caterpillar LGP D8 tractor; however, the building was extended by using timbers, cable and canvas. Considerable work was accomplished outside of the garage on the D8 tractor by using a tarpaulin, a Herman Nelson heater, and a floodlight trailer. By using this arrangement, a starting engine was changed on a D8 tractor at -65 F.

South Pole

The tools delivered to the Pole Station by the construction party were gathered at McMurdo with the idea that all tools would be left there upon evacuation of the construction personnel. Additional tools for maintenance were requested, primarily shop tools, and were delivered late in January or February 1957. There are no shops as such at the Pole Station, only a large area in the power house and garage which must serve for equipment storage and any other shop work desired.

STARTING AIDS

Stewart Warner Coolant Heaters (Model 939A)

The South Wind 939A was ineffective at McMurdo as it did not warm the oil. At Little America, the effectiveness of the coolant heater was found to vary with the wind conditions, the type of motor oil, and the piece of equipment involved. With no winds and 9170 oil in the crankcase, the heater was effective in a weasel to -20 F; in a Sno-Cat to -30 F, and in a D8 tractor to -45 F. Using sub-zero oil in lieu of 9170, the heater was effective in a weasel and a D2 tractor to -50 F; and to -55 F in an HT-4 traxcavator. "Experiments in -56 F have proven the 939A coolant heater to be inadequate in furnishing enough heat to properly heat engine oil. Tests have lasted as long as 10 hours and then stand-by heat was necessary to heat engine oil to a temperature where it would drip off the dip stick."[19]

Kim Hotstarts

They are a fine attachment and do a lot of good on small engines, but in extreme cold weather the electric cord is as brittle as glass and the rubber insulation breaks off the wire. It is believed some kind of cloth would be better insulation. Kim Hotstarts required electrical power which was not available at the McMurdo runway, or on the ice. When the tractors were near the garage, the electric heater was used and proved effective.

At Little America, Kim Hotstarts were unsatisfactory for the D8 tractor in that the Btu output did not appear large enough for the size of the engine. This piece of winterization was tried leaving the Kim Hotstart plugged in for 16 hours at approximately -50 F; this failed to maintain the heat present at the time of securing the piece of equipment. They were not satisfactory in the M29 weasels, D2 tractor or HT-4 traxcavator, as the heat transfer was not sufficient to preheat the coolant.

Ether Primers

At McMurdo ether dischargers deteriorated the rubber or neoprene seals and the cold weather made them brittle; small pieces would break off and clog the discharger. When personnel unscrewed the cap on the discharger, the ether would sometimes spray into the operator's eyes. "Most copper tubing vibrated off after two months operation. Believe steel tubing and solid mounts required on cabs and engine covers to give satisfactory job."[5] Ether primers were not required at Little America to start the D2 tractor or the HT-4 traxcavator, provided the engine was properly preheated. They were not used on the weasels.

POLAR FIELD REPAIR KIT

The Polar Field Repair Kit is a 1200-cubic-foot portable repair shop with a van-type body mounted on a toboggan sled. This portable repair shop was designed by the Naval Civil Engineering Laboratory, Port Hueneme, California, and was equipped with a 20-kw generator, hand and power tools, and necessary welding equipment. A windbreak was fabricated from dunnage. This offered some protection and comfort to the mechanic working on equipment.

The repair kit was among the first pieces of equipment to be off-loaded on the ice and was put into operation immediately. During the first phase of the ships unloading operation, the repair shop was located a quarter of a mile from shipside; communications with the ships was made by radio. Two 12-hour shifts were established with the senior mechanic in charge of each shift. After each piece was unloaded, it was checked and serviced before being put into operation. Typical examples of some of the various jobs accomplished working from the portable shop were: installation of bulldozer blades, catwalks, 20-foot booms on D8 tractors and the assembly and services of other types of equipment. The only failure of this unit was the failure of the automatic control panel (voltage regulator) of the 20-kw General Motors 371 diesel generator. A replacement unit was ordered. The repair kit was later incorporated as an annex to the garage. "The Polar Field Repair Kit was the backbone of maintenance. The only major trouble was with the controller for the generator."[5]

SPARE PARTS

It was felt that if the spares were shipped in a unit, such as a spare parts van, it would save time and material. This was part of the recommendations to BuDocks.

MATERIALS PERFORMANCE

Rubber

Insulation on battery cables cracked in relatively warm temperatures. The necessity to change batteries often in cold weather makes this an important failure. Hydraulic hoses failed excessively at -40 F and lower until replaced by aircraft hose, Spec MIL-H-5511. Seepage was evident in the 3000 and 10,000-gallon rubber POL tanks, exposed all winter and constantly inflated and deflated. The rubber hose of bulk fuel systems held up satisfactorily. Fifty-gallon rubber tanks became hard as concrete when subjected to low temperatures. No adverse effects to the containers were noticeable after thawing out.

Other Materials

Pipe valves (gate) froze up and broke extremely easily. Measures must be taken to keep the valves from freezing.

Canvas products caused no trouble at the low temperatures, although roof tarps became excessively stiff during installation.

The landplaner, roller frames and drag towing gear showed evidence of excessive failures during the cold weather. The failures appeared as brittle fatigue-type failures. Metal chains on the 20-ton sleds became brittle and broke easily in low temperatures.

Every D2 track frame had cracked and had been welded by the end of the year. This appeared to be a case of design rather than material failure although cold weather could have had something to do with it. Extreme vibrations in over-the-ice work is hard on equipment.

Linoleum became very hard and brittle and could not be used until thoroughly thawed out.

Special attention must be paid to annealing welds, preheating material, and cooling slowly in cold weather. Welders should have special training prior to departure to cold-weather areas.

Aluminum nails were not satisfactory for work in the cold. They are too soft and ductile for driving. Many nails were wasted due to excessive bending. Steel nails are recommended.

RADIO INTERFERENCE SUPPRESSION

"There was quite a bit of trouble with the radio suppression at McMurdo. A lot of the suppression equipment broke down and burned out.

When the filter choke in the voltage regulator of a tractor would burn up it would cause the ammeter to burn out and leave the circuit between the battery and the generator open. Thus the battery got no charge and went dead. If this suppression is as important as it is stated, the men will have to be trained for it and given the equipment to do the job. As it was, a lot of money was spent to suppress all our equipment and we had to remove most of it."[7]

"In the weasels, the RIS gear constantly grounds out, burning out the voltage regulators, etc."[5]

Section XV

SCIENTIFIC AND RESEARCH PROGRAM

IGY STUDIES

The International Geophysical Year officially commenced on 1 July 1957, with the IGY personnel conducting studies in the following fields of science:*

Aurora and air-glow sky observation and photography to record auroral phenomena and meteors. - All Stations

Biology - Wilkes Station

Cartography - Wilkes and Ellsworth Stations

Cosmic Rays - Wilkes Station

Geomagnetism - Surface observation to provide data regarding temporal changes in the magnetic field of the earth. - All Stations

Glaciology - The study of antarctic ice sheet. - All Stations

Gravity - Little America and Wilkes Station

Ionospheric Physics - All Stations

Meteorology - Gathering weather data. - All Stations

Micrometeorology - The study of meteorological factors close to the surface of the snow. - All Stations

Oceanography - The study of ocean water temperatures, salinity, and tides. - Little America

Physiology - The study of human acclimatization to cold. - Little America and Byrd Station

*Reports on McMurdo and the Ellsworth Station do not contain complete information on the disciplines studies at these bases.

Seismology - Obtaining data on the thickness of the Ross Ice Shelf and depth of water underneath. - All Stations

Zoology - Wilkes Station

Byrd

In the Spring a traverse party departed from the Byrd Station to study the geological and other related phenomena around Marie Byrd Land.

South Pole

During Deep Freeze II there were nine IGY scientific personnel at the South Pole Station. A deep pit, combined with the snow mine, was used for surface and deep glaciological studies. The spectograph and all-sky camera employed in aurora and air-glow studies gave considerable trouble.

Wilkes

In order to extend the meteorological and glaciological programs, a small icecap station was erected 50 miles inland from Wilkes. This was erected in early April 1957 and manned all year long. Routine weather observations were made there and the glaciology deep pit was dug there during the winter. The station consisted of one 16-foot Jamesway section and adjacent snow tunnels and storage areas.

Ellsworth

A traverse party departed on 28 October 1957 for the interior of Edith Ronne Land. This party continued until 16 January 1958, when they had to abandon Sno-Cats about 250 miles southwest of the station in order to be flown back to the station to board ships departing the following day.

NAVIGATION AND SURVEYING

McMurdo

During the construction period, December 1955 through March 1956, a group of surveyors of the U. S. Navy Hydrographic Office were located at Hut Point. They established a basic triangulation net for the area immediately surrounding the air facility establishment, and took continuous solar observations to establish the positions of the net. The results of this work are published in the report of the Hydrographic Office for Deep Freeze I. A Navy surveyor worked in close conjunction with the Hydrographic Office representative.

During the winter months, celestial stellar observations were made by the construction officer to verify the solar observations taken during the summer. Wild T-2 and T-3 theodolites were used for this work. The position of a point midway between buildings #2 and #3, and 20 feet from the front of these buildings, was computed graphically as being 77°50.97'S and 166°39.9'E.

The runway direction was also determined celestially, as the inaccuracies of the magnetic compass are so great in this area (the horizontal component of the magnetic force is weak and the dip is so great that the compass is difficult to use accurately at McMurdo). The direction of the center line of the ice runway was found to be 264.5° - 84.5° True.

Grid navigation is used a great deal due to the rapid convergence of meridians at this latitude. The grid system arbitrarily designates the directions of the prime meridian as North and South, the north end being toward Greenwich. Parallel and perpendicular lines are then drawn with respect to the Prime meridian. (Refer to Chapter XVIII of Dutton's "Navigational and Nautical Astronomy.") A person's grid heading is always his true heading plus his easterly longitude or minus his westerly longitude. In this manner, since the runway longitude is 166°30'E, the grid directions are: 264.5° + 166.5° = 431.0° - 360° = 71.0° grid, and 84.5° + 166.5° = 251.0° grid.

South Pole

Polar Navigation

Method. Due to the unique location of the South Pole Station, a singular method of navigation was able to be used for precisely locating the Pole itself. This method is outlined in Dutton's "Navigational and Nautical Astronomy," Chapter XVIII entitled "Polar Navigators," Section 1805. The method is accurate as long as the observer is within 2 degrees of the Pole. The basis of the method is the principle that the declination of any body and the altitude of that body are the same when an observer is at either Pole, inasmuch as the planes of the celestial equator and the planes of the horizons at either Pole coincide (are parallel). If the assumed position (AP) of the observer is chosen as the Pole, azimuth becomes Greenwich Hour Angle (GHA). H_c, the computed altitude, can be taken directly from the declination tables for any GHA. H_o, the observed altitude, can be obtained by applying corrections to the H_s, instrument altitude. Thereafter, the line of position is plotted as any other sight is plotted, depending on the relative sizes of H_o and H_c, to determine if actual position is toward or away from the observed body. Figure 1805C of the reference shows a simple two-observation fix.

Declination. The declination for the sun, the only body visable (the moon could be seen very rarely, and never could be used), is given in the Nautical Almanac to 0.1-minute (600 feet). This is not accurate enough for precision work. Since no other tables were available, the tables from the Nautical Almanac were plotted to a large scale and a smooth curve was drawn through the plot. In this manner, declinations were estimated to 0.01-minute (60-foot) accuracy. The T-3 sights were then reduced to the same accuracy.

Time Considerations. Since the declination of the sun changes very slowly over a period of time and since the altitude equals the declinations, the observed altitude changes very slowly, and precision time is not important in computing H_c, the computed altitude. Time is important only for computing azimuth (equal to GHA). In taking twelve observations, the time was observed in starting and in ending, and the average time was used for the computations. A matter of 5 minutes has very little effect on altitude observations.

Corrections. When pinpointing a location within a self-imposed 0.25-mile limitation, the correction for temperature and barometric pressure must be applied, especially if they vary greatly over a 24-hour period. The temperatures during which observations were taken at the South Pole varied between -35 F and +5 F. The normal barometric pressures were about 20.5 inches of mercury. The corrections for this unusual set of circumstances were quite large and of questionable accuracy. They are given in the K & E Solar Ephemerus to 0.01-minute. This imposes a limitation to the accuracy of the reading when the T-3 Wild theodolite used reads to 0.1-second (10 feet) and estimates to 0.01-second (1 foot). More accurate tables would have been welcomed to correspond with the accuracy of the instrument used.

The best method of obtaining accuracy in making an observation, especially when the characteristics of an instrument are not known, is to take an upper limb and a lower limb observation, then dip and reverse the scope and take another set of upper and lower limb observations. The average of these four shots will eliminate the instrument error and the corrections for semi-diameter. The only corrections to be applied then are for parallax and refraction, the latter being further corrected for temperature and altitude. The shot should be taken every three hours for 24 hours so that an eight-sided polygon formed of LOPs will result. The actual method used at the Pole was to make twelve simultaneous observations of the sun's lower limb and take the average. The instrument error was known to be about 0.25-minute , an error of magnitude of approximately equal but opposite sign to an error experienced in the refraction table corrections. Since instrument errors are constant and cancel out when round-the-clock observations are made, and since the correction for semi-diameter is almost constant for any short period of time (one to two days) and cancels out when round-the-clock observations are made, the method was not too inexact under the circumstances.

Shots were taken over a period of three days; a six-sided polygon resulted, and located the actual Pole approximately 0.2 mile from the Pole Station camp. This determination represented a total of 72 observations. The position will be checked by stellar observations this winter. Above all, with corrections being so important, 24-hour round-the-clock observations are required. An excellent plotting sheet for field work and for final computation for this particular case was found to be a standard maneuvering board sheet.

The unknown error in all of the Pole Station computations was that of gravity irregularities, a scale of which was impossible to obtain. It was assumed that the horizontal plane indicated by the bubbles of the theodolite was true horizontal. This error is not eliminated by 24-hour observations and its effect might be considerable, depending on the nature of the geological structure beneath the plateau.

At the Pole itself, grid directions are simple to use, as the GHA of the sun gives a constant reference to grid direction (or meridian). At any other South Polar area the following formulae are used to convert Grid Direction (G) to or from True Direction (T), knowing the East or West Longitude (λ E and λ W):

$$G = T - \lambda W$$

$$G = T + \lambda E$$

$$T = G + \lambda W$$

$$T = G - \lambda E$$

By choosing any spot, say point A at 135°E longitude, true bearing south, the grid bearing is:

$$G = T + \lambda E$$

$$G = 180^\circ + 135^\circ = 315$$

Point B, 135°W longitude with heading due west, true, results in:

$$G = T - \lambda W$$

$$G = 270^\circ - 135^\circ = 135^\circ$$

Notice that these signs differ from those given in Dutton, which are used for the North Polar area. Another system, almost identical, was used at the Pole to designate direction: This merely stated direction in terms of true meridian (e.g., wind is out of the 130°E, the train ran from 125°W, etc.).

Precautions

When working in the cold, the instruments must be delubricated and left in the cold at all times. A change in temperatures, as when the instrument is brought indoors, causes condensation and trouble beyond compare. A stiff instrument at -35 F is impossible to use with accuracy, and once condensation forms inside an instrument built with such precision as a theodolite, it becomes stiff.

Surveying or navigating in the extreme cold is perhaps the coldest job ever undertaken. Light gloves are necessary to adjust the instrument and to prevent "burning" of fingers on the cold metal. Frostbite on the face is common when making high-altitude observations, as the face invariably touches some part of the instrument (a prism is recommended for these observations). Chaomois, glued to all adjustment knobs, will help keep frost burns to a minimum. Plastic knobs would help. When taking night-time stellar observations, batteries illuminating the scales soon become powerless in the cold. Two battery boxes are suggested, one always being warmed while the other is being used. Moisture from the breath continually condenses on the lenses, causing further distractions. Care must be taken continually to prevent breath from being exhaled directly onto the instrument. If the instrument has been kept inside, let it cold-soak before using it, as the differential contractions will cause great inaccuracies in readings. If possible, let the time and note keeper remain inside a shelter (tent or building) where he can hear the observer, but where he is relatively warm.

Wilkes

Surveying

The surveying at Wilkes can be divided into five operations. The first of these involved erecting a system of cairns in the area to the north of the station and gathering enough information for a reconnaissance type of map. The second was a rough survey of the ice cliffs from the end of the Windmill group to Cape Folger. The third was a one-day survey of the Balaena Island group. The fourth was a topographical survey of the immediate camp area. Last was the establishment of three cairns and the beginning of transit work on Midgley Island. The work was done by personnel without previous surveying experience and largely under adverse conditions.

The erection of the cairn system was started from Wilkes Station and extended to the north end of the Windmill group. The astronomical station established by R. J. Berkley, and the two large rock cairns erected by Dr. Tressier of the Hydrographic Office during the summer of 1956-57 were used as the starting points for the system which, when finally completed, included 12 additional rock cairns. The transit was set up over each

cairn and angles were measured between as many other cairns and prominent features as possible within the available time. Photographic panoramas were taken from 10 points to cover the area of the survey. A base line of about 4000 feet was measured by a combination of tape measurements and stadia shots over open water, another of about 900 feet made by taping between two cairns, and a last one of a thousand feet made by taping between two temporary markers set up on the sea ice. As many intercairn distances were calculated as possible from the available measured angles, and the system was plotted to a scale of 2000 feet to the inch. At this scale there was no discernible error of closure after inconsistent angle measurements had been deleted. Stadia rod sights to the sea ice from a number of these cairns were taken and the vertical angles between most of the more closely grouped cairns were measured for the purpose of approximately determining elevations. A rough map of the shore line of the area was drawn from the triangulation net and the panoramas.

For the determination of the ice cliff configuration from the north end of the Windmill Island group to Cape Folger, a system of removable markers was used. These were set out on the sea ice adjacent to the ice cliffs and located with the transit from the end of the cairn system. At approximately half the distance to Cape Folger a temporary base line of about 1/2 mile was set out for use in extending the work to Cape Folger. From each of these temporary markers, stadia distances to the bottom of the ice cliff front and vertical angles to the top of the cliffs were taken.

The survey of the Balaena Islets was considerably limited by the time and consisted of two solar altitudes taken on different days and two solar azimuths plus rough transit work from the two cairns erected there by the Australians.

The work on Midgely Island was limited by bad weather and the fact that the access to the island ended shortly after the work began. The Midgley site has many advantages as a focal point for future work. Wilkes Station proper is clearly visible from there as is the area to the South. The hill on the island is fairly high and Frazier Island is easily seen. Also the area immediately adjacent to the island is not too accurately described by present maps. Three cairns were erected on the summits of the island's hills, a few angles were measured, and the distance between two of the cairns was measured by stadia rod.

It is felt that with slight additional work the mapping of the entire Windmill Island group can be completed with map quality as good or better than available maps on the southern portion. Helicopter photos of this unmapped area would be of great value. Both the position established by Mr. Berkley and that established by the Russians in the area between Bailey and Mitchell Islands seem to indicate that the maps of this region

are based on a questionable astro fix. It is felt that this should be corrected. The available maps of the islands are in general excellent and highly accurate but could be greatly improved by a systematic attempt to remove the errors which resulted from difficulties in photo interpretation. The biggest deficiency in the work done this year is believed to be the lack of a definite tie-in of this year's work with the other maps; this will, if possible, be corrected before the end of this year's operations.

GEOLOGY AND PHYSIOGRAPHY

The Hut Point Region - McMurdo Sound*

McMurdo Sound base is sited between Hut Point and Observation Hill. This area lies on the southwestern extremity of an 8-mile-long ridge extending from the foot of Mount Erebus. The southeastern slope of this ridge is for the most part covered by a 2-mile-wide Highland Icesheet sloping down to the Ross Ice Shelf. The crest of the ridge is surmounted by a chain of ten extinct volcanic cones which rise to a maximum altitude of 1400 feet. Part of the steeper northwestern slope of the ridge, together with the slopes about the projected camp site, are snow-free in the summer.

Geology

All rock types mentioned have, as yet, been classified in the hand specimen only. The rocks of the Hut Point area are all igneous with the exception of small pebbles of biotite granite and gneiss which occur sporadically in superficial deposits. Their occurrence on the summits of unmodified cinder cones and the absence of larger eratics in this locality denies a glacial origin. Debenham describes them as being windblown, but there is no apparent sorting or removal of the finer local tuff. An origin as fragments of basement rock is possible, caught up and ejected with the scoria, but granite inclusion have not been found in any local volcanic rock. Feldspar inclusions as aggregates do occur, however.

The earliest eruptives appear to have been a series of basic flows of early or pre-Pleistocene age. This series would include the fine grained Olivine basalt of Hut Point itself and the vesicular basaltic basement of the camp site as a late differentiate. The dissected hornblende trachyte cone of Observation Hill was built up of steeply dipping flows, possibly together with the plug breccia of Castel Rock.

* From a report by Mr. B. M. Gunn of the University of Otago, New Zealand

These earlier rocks show signs of extensive glacial erosion in the horn-like shape of Observation Hill, the U valley between it and Crater Hill, the mammillated outline of Hut Point and the flattened to gently rounded crest of the ridge as a whole. The angular outline of the Castle Rock breccia plug can only be ascribed to lateral erosion by ice moving from S. E. to N. W., with later sapping at the foot of the S. E. wall by the present ice sheet.

A recent acidic phase has given rise to the chain of ten cinder and scoric cones which surmount the ridge. A final explosive phase, apparently from local craters, has left a veneer of unconsolidated scoria and lappilli tuff over the greater part of the Hut Point area. These scorlaceous fragments contain large crystals of horneblends and pure nodules of olivine up to 8 centimeters in diameter. Flattened lava blebs and striated bombs on the flanks of Crater Hill indicate the recentness of this phase. Crater Hill is also cut by radial trachytic dykes. The linear arrangement of the cones suggests they are sited along a structural rift of the type seen in Mt. Morning, Minna Bluff, and the Black and Brown islands.

Physiography

The secondary processes bringing about the evolution of a landscape resemble those of a tropical desert. Annual precipitation estimated at 18 centimeters, vegetation limited to lichens and algae, strong winds, and great annual temperature changes all have desert affinities. These effects are strongly modified by the permafrost. Soil profiles were inspected by digging and dynamiting the permafrost at the camp site. A typical profile on a ridge was as follows:

1. A thin, superficial lag gravel.

2. Thirty to 40 centimeters of yellow to brown tuffaceous material, unsorted, and ranging in size from 50-centimeter-diameter bombs and angular basaltic fragments, to sand, silt and clay. A settling sample showed a 5-percent clay fraction.

3. Twenty-five centimeters of dark grey, gritty, finely comminuted skeletal "soil."

The top of the permafrost was usually in this layer, forming a plane surface parallel to the ground surface. The water content of one tested sample was 18 percent. Fine veinlets of ice were present. In the lower parts of this layer, the rock structure was preserved with olivine crystals in place, but disintegrated on warming in the sun. About 8 centimeters of vesicular basalt contained ice on the vesical but retained its solid structure. The bedrock of vesicular olivine basalt was ice-free. In these zones of shallow permafrost, a polygonal surface was either absent or poorly developed in polygons of more than 10 millimeters in diameter.

The profile of below-surface depressions was of a different pattern:

1. An upper layer of 30 to 40 centimeters of fragmentary ejecta was saturated with snow meltwater.

2. The permafrost layer was in the same material. Ice wedges 23 centimeters wide and of unknown length and depth were encountered. Bedrock was not reached at a depth of one meter. The "soil" tended to be finer, due to inwashing by meltwater, and the boundaries of the polygons were more deeply incised. They were correspondingly smaller in diameter (2 to 3 meters) with secondary polygons developed within them.

The superficial polygon structure appeared here to be due to tension-cracking of a thawing and drying surface in the spring period. There was no concentration of coarser material along the polygon boundaries that could not be explained by accidental toppling of fragments into the crevices, and some removal of fine particles when the boundary of a polygon chanced to coincide with natural drainage.

Recent Glacial Action

Small moraines are found horizontally below permanent snow patches, as on Crater Hill, and so some movement and erosion is taking place. Frost riving, exfoliation, and rock spalling are active on all exposed surfaces.

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